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ABSTRACT

This syllabus is organized into 17 sections (or "maps") which focus on these topic areas: the earth in the universe; variety and adaptation; reproduction; growth; food and feeding; sensitivity; microscopic living things; movement, forces, and structures; heat; light and color; sound; magnets and magnetism; electricity; water and other liquids; air and other gases; materials; and rocks and minerals. Each map consists of two parts and a sample scheme of work. The first part describes core investigation techniques in detail. Examples are given of the kind of question or idea which can start an investigation, the kind of experimental planning to be done, the kind of causal explanations students might give, and problems which might be tackled. A complete list of core techniques is given for the collecting of evidence, recording, calculating, and looking for patterns. The second part describes the development of scientific ideas in three categories: core ideas (which can be grasped by 13-year-olds); supplementary ideas; and extension (abstract) ideas. The sample scheme of work lists (with references) a variety of activities teachers can use. Information on using the maps in program planning, principles underlying a description of core science, and core science within the whole curriculum is included. (JN)

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The Middle Years Science Curriculum Project

CORE INTENTIONS FOR

SCIENCE IN THE MIDDLE YEARS

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FOREWORD

I am most happy to commend this document to the close attention of all those who have a part to play in the teaching of Science to pupils in middle schools. Much work will be involved in implementing the proposals indicated in this document and the active participation of all teachers of Science in primary and secondary, as well as in middle schools, will be the most effective way of achieving the forward movement for which this document prepares the way.

It is during the period between 8 and 13 that children begin to develop a curiosity about the wider world in which they live and seek to codify into a coherent pattern what they have observed. To take best advantage of this natural curiosity and to assist the acquisition of the fundamental concepts of Science, work has been under way for more than three years to develop the core of a Science curriculum for the middle years in Leeds schools. The work has been a fine example of cooperation between the teachers of Science in middle schools, most of whom, with the encouragement of their Head Teachers, have taken an active part in the research programme on which this Science curriculum project is founded. To all those teachers in middle and high schools who have contributed time, effort and careful thought to work with the Project my thanks first of all are due; secondly to the staff of Trinity and All Saints' College, the University of Leeds, the Leeds Polytechnic and the College of Ripon and York St. John, who made secondments possible by substituting for the teachers in their schools; thirdly and most particularly to Mrs. Ann Squires for her energetic and devoted leadership as the guidance of the Project has rested in her hands.

I am delighted that the Project has now reached the point of publication of its work and that we can all now look forward to the application of the Project's findings to the Science syllabus of all Leeds middle schools.

R. S. Johnson

Director of Education

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1. INTRODUCTION

The organisation and purpose of the Middle Years Science Curriculum Project

In 1971, the year before middle schools were introduced in Leeds, a working party of middle school science teachers designate began to think about the science curriculum for the middle years. They wanted to encourage a science curriculum which encompassed the best of junior and secondary approaches and they looked forward to thinking afresh about what science could offer to pupils.

The value of a recognised core within the science curriculum began to emerge later, when it became clear that considerable common ground already existed. The problems of high schools receiving pupils from a large number of middle schools highlighted the need to confirm and describe this common ground. This was obviously a task for all the middle school science teachers of the Authority rather than for the relatively small group of the working party. Accordingly, in January, 1977, the Middle Years Science Curriculum Project began its three-year programme of work.

This project received the whole-hearted support of the head teachers of middle schools and a Consultative Committee was entrusted with the task of representing their interests and overseeing the work. It was proposed to draw upon the experience and expertise of all middle school science teachers and upon the support and involvement of high school colleagues and the staff of colleges and departments of education.

The Project was organised by a member of the Authority's Research and Planning Section who was allocated two days each week for the work. In each of the three years of the project's programme four teachers were released from school for the equivalent of one day per week to undertake co-ordination work.

The release of teachers from school was made possible by the generous participation of members of the staff of Trinity and All Saints' Colleges, Leeds Polytechnic School of Education, and the College of Ripon and York St. John. Staff of these institutions undertook teaching commitments in Leeds middle schools, so enabling the science teachers of those schools to act as project co-ordinators.

The work of the project was shared among all the science teachers of middle schools. There were 59 middle schools, including five 8 - 12 schools, until 1979 when the inception of eight Roman Catholic middle schools brought the total to 67. Each school was visited initially by the organiser and an LEA adviser for the purpose of agreeing aims and the procedures for sharing the task among all science teachers. The task of identifying and describing core science was shared in such a way that each teacher worked upon one or more areas of science according to his or her particular interests.

Work began from the premise that the science curriculum for this age group should offer a balanced and comprehensive introduction to the subject. This principle is helpfully expressed in the following passage from the writing of J. F. Eggleston:

> If one takes the view that each subject has some irreducible [1]

conceptual structure which can be thought of in terms of a map, then one criterion which might be used in selecting the content of a course is the contribution any topic makes to providing important components in that map, and hence to helping a pupil to 'find his way around' a subject. For some pupils we might consider that a 'world atlas' view is adequate, whereas for the researcher in a discipline a 'three inches to the mile Ordnance Survey' map will be required in his area of special interest. Maps with bits missing, however, may result in getting lost, misinterpreting the terrain, and not proceeding with confidence from base. *(1)*

The whole terrain of science was therefore divided, for convenience of working into the 17 areas of the maps which follow in Section 4 (p 21) and a small group of teachers, usually between 6 and 12, worked upon each of these. Each group set about the task of mapping the scientific ideas relating to its chosen area of science, identifying those which might be considered core ideas as distinct from the less important or difficult ones. Later their attention was focussed upon related scientific ways of working in each area. Many groups benefited from the involvement of the staff of colleges and departments of education and each group was supported by one of the teacher-co-ordinators.

The discussion papers prepared by the groups, referred to as 'maps', were circulated for detailed criticism to all other middle school science teachers (most of them at work in other groups), to high school science colleagues; to LEA advisers, and to science staff in colleges and departments of education. Critical responses where then collated and considered before the 17 groups prepared the maps which are presented here.

It was the role of teacher-co-ordinators to administer the preparation, distribution, and criticism of preliminary versions of maps; and to ensure that important issues were raised and difficult decisions taken.

Groups worked primarily from the concerted experience and intuition of their members. Objective evidence to support their decisions was rarely available and research into pupils' successes and difficulties was beyond the scope of the project. One group however, that concerned with heat, benefited from collaboration with the project 'Concepts in Secondary Mathematics and Science'. *(2)*
This project had been concerned with pupils' conceptual development and its investigations and analyses provided valuable information about pupils' understanding which influenced the selection of core ideas. In the area of heat tasks for pupils were developed for the purpose of evaluating and revising the proposed core.

The description of core science amounts, therefore, to an hypothesis for testing and *it will need to be revised in the light of future experience*. It sets out in detail those scientific skills and ideas which teachers believe pupils could and should gain by the age of 13, given that schools will adopt a variety of individual approaches.

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(1) Eggleston, J.F., Science Teacher Education Project: The Art of the Science Teacher, McGraw-Hill, 1974.

(2) Concepts in Secondary Mathematics and Science Project: funded by S.S.R.C. and directed by Professor P. Black and Michael Shayer, at the Centre for Science and Mathematics Education, Chelsea College.

it is offered to middle school science teachers as a basis from which to build their individual curricula and to guide colleagues who contribute to science teaching. It is offered to high school science teachers as a detailed account of the skills and ideas which the majority of thirteen-year-olds will have begun to develop, and from which a smooth transition from middle school to high school work can be planned.. The teachers who took part in countless meetings, arguing, justifying, criticising and finally reaching agreement, consider that part of the value of the project lies in that process of collaborative curriculum design which not only drew upon their expertise, but which gave them considerable opportunities for professional development. They hope that this written outcome of their work will continue to stimulate discussion and collaboration, particularly in the context of liaison meetings between teachers from different tiers of schooling, and that this first attempt to identify the core of science for the middle years will be refined and improved.

2. PRINCIPLES UNDERLYING A DESCRIPTION OF CORE SCIENCE

2.1 The concept of a core of science

The middle school faces the difficult task of making a smooth transition from child-centred investigations characteristic of primary science to the subject orientated work of secondary schooling. One of the main aims of middle school science teaching is to continue, and foster, the spirit of personal inquiry as greater attention is given to pupils gaining the skills and ideas of the subject.

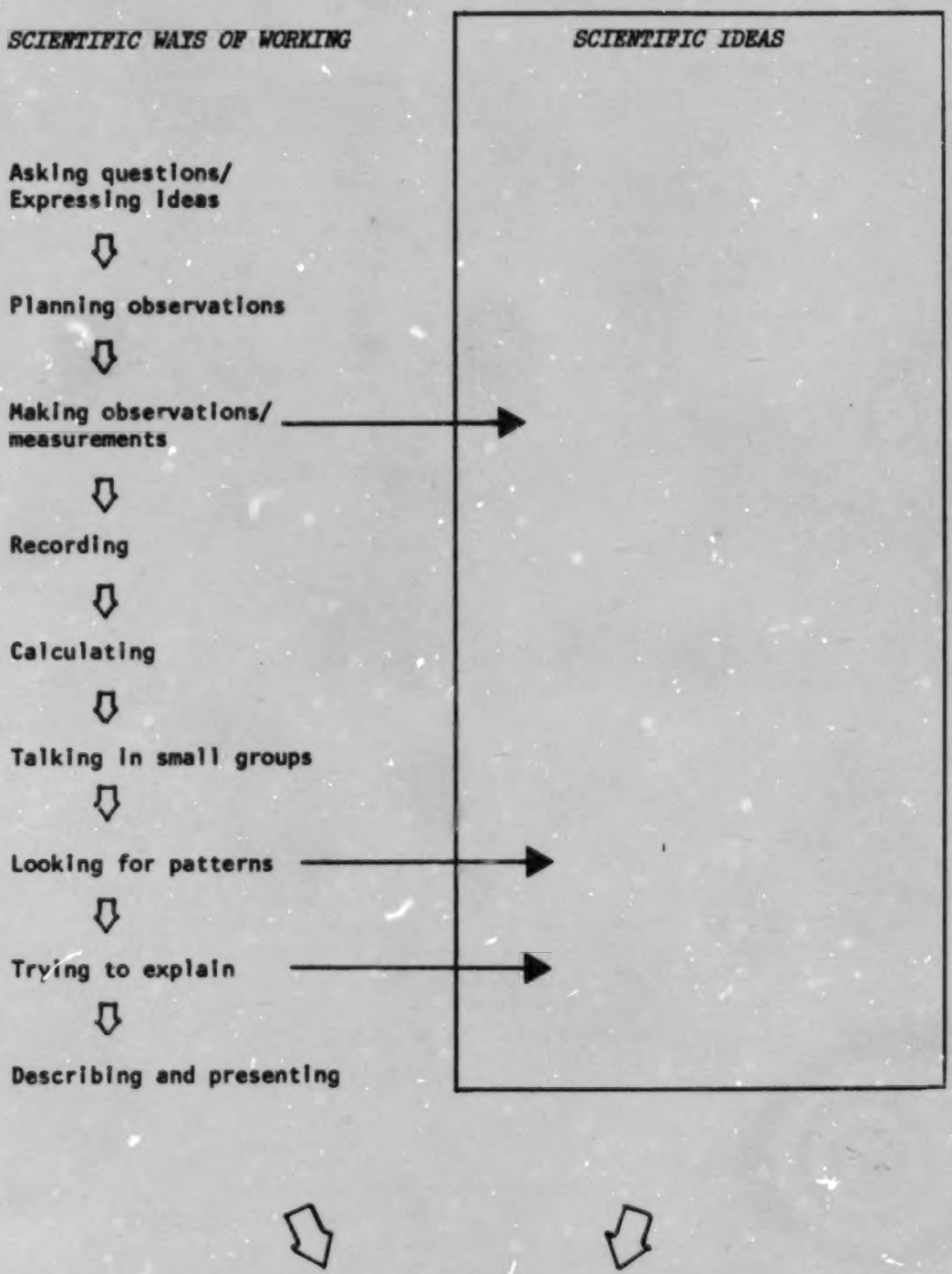
Clearly a core syllabus, which specified particular activities for pupils, would be in serious conflict with the spirit of inquiry we want to promote. Furthermore, it would usurp the role of the teacher who should be free not only to select and design activities appropriate to particular pupils, but also to respond to needs and opportunities which arise.

Nevertheless, when pupils make wide-ranging investigations they are almost certain to acquire characteristic skills of inquiry and they are almost certain to develop many of the fundamental ideas about materials, about living things, and about forms of energy. Indeed when teachers involve children in investigations they make use of the opportunities which then arise to ensure that scientific skills and understandings do emerge from pupils' explorations.

It is these expected skills and ideas which form the core defined in the following maps. They describe core intentions which teachers expect to fulfil in a variety of ways.

Science is made up of two inter-related aspects: on the one hand practical and intellectual techniques of investigation - scientific ways working; and on the other hand those understandings and concepts which emerge from investigations - scientific knowledge. We must recognise, in addition, a third component, that of using skills and knowledge to solve problems and to make useful things, namely Technology.

All three components are represented in the core of the science curriculum for the middle years. These are shown diagrammatically opposite.


SCIENTIFIC WAYS OF WORKING
SCIENTIFIC IDEAS
Asking questions/
Expressing ideas
Planning observations
Making observations/
measurements
Recording
Calculating
Talking in small groups
Looking for patterns
Trying to explain
Describing and presenting
Making use of scientific skills and ideas

2.2 Scientific ways of working

Science for younger pupils usually takes the form of first hand practical investigation.

The process of scientific investigation can be considered as a set of techniques, some of them practical and some of them intellectual, which are used together in exploring the environment. Science involves having ideas, collecting evidence, handling the evidence and making use of skills and ideas. Investigation usually follows a sequence:

(1)

Having ideas

We raise a question which we want to answer by observation or experiment

or We express an idea which we want to put to the test in practice
(e.g. Balls bounce higher on a hard surface than they do on a carpet).

(2)

We plan a set of observations or an experiment designed to answer our question or test our idea
(e.g. We select surfaces to test and decide what to measure).

(3)

Collecting evidence

We carry out our observations, often using optical aids, measuring equipment and other simple apparatus some of which we may have designed and made for the job
(e.g. We measure the height of bounces, taking care to drop from the same height).

(4)

Handling evidence

We record our observations and measurements in words, drawings, models, or in table-form
(e.g. We record the height of bounces in a table).

(5)

Sometimes we need to make calculations from the measurements we have made
(e.g. We calculate an average bounce for each surface).

(6)

We talk together to explore ideas about our work.

(7)

We try to find patterns in our observations: sorting into sets, putting into order, or looking for relationships which help us to come to conclusions from our investigations *(e.g. We arrange surfaces in order of hardness, by feel, and look for order in the height of bounce. We find that the harder the surface the higher the bounce).*

Handling evidence

(8)

We try to explain the patterns that we find in our observations, at first in terms of cause and effect and later by theories
(e.g. We propose that balls bounced higher on hard surfaces because these do not 'give' when the ball falls).

(9)

We describe and present our observations and conclusions for the benefit of others.

(10)

Making use of scientific skills and ideas

We put our skills and knowledge to good use in solving new problems or making useful things
(e.g. We choose the best surface for a children's ball game).

This sequence of skills is one major component of the core of the science curriculum. It is the means by which pupils will develop their scientific ideas in most of the areas of science. The maps which describe the core of each area of science begin by describing the related skills of investigation, although in some cases, notably Reproduction and The Earth in the Universe, practical investigation is not possible and audio-visual aids replace first-hand experience.

Each one of the sequence of investigation skills is of course capable of development throughout the years of middle schooling. Pupils learn to generate more useful questions and to offer more precise ideas for testing. They learn to observe more acutely, to use optical aids more skillfully, and to measure more accurately. They become more articulate in discussion and more perceptive in seeing relationships and patterns in their experiences. They become more interested in explaining the patterns that they find and more inclined to explain in terms of what might be happening 'behind the scenes'.

The skill of finding patterns, or drawing conclusions, from investigations is the one which leads to the development of scientific ideas. It is a selection of these, the more important and more simple ones, which make up the other major component of the core of the science curriculum.

2.3 Developing scientific ideas

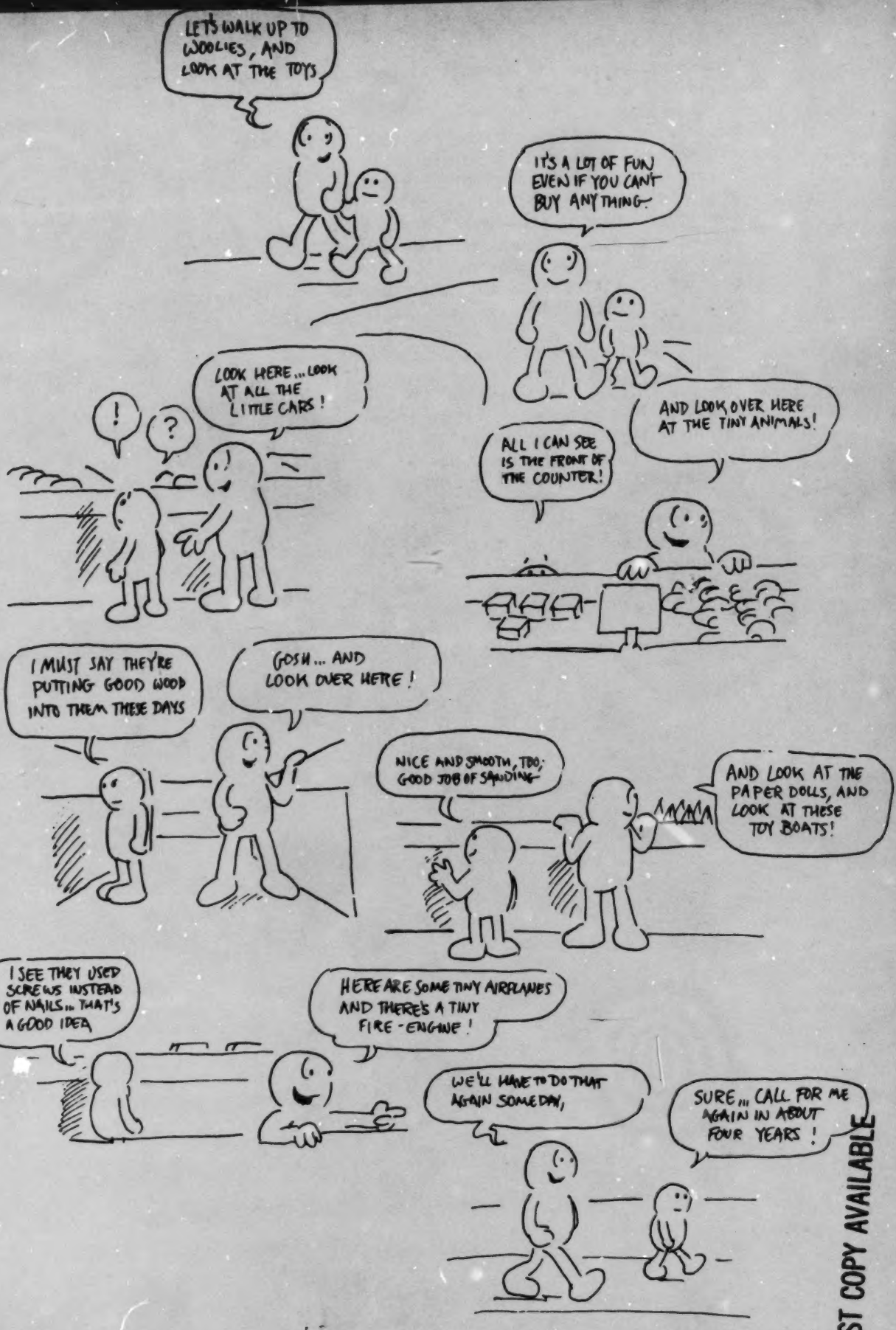
Pupils usually develop scientific ideas from first hand practical investigation. As their experience is widened and reinforced their understandings undergo change and development. An idea is therefore introduced, developed, reinforced and refined over a period of many years, often extending before and beyond schooling.

For example, young children are likely to begin with the mistaken idea that all big things are heavy. From experience of a variety of materials they come to revise the idea and to recognise that size is not the only thing that affects an object's weight. After more quantitative work with materials, weighing and measuring blocks, or using equal-sized pieces to make things fair, pupils begin to recognise that certain materials are light for their size and other materials heavy for their size. All these ideas are steps towards a more formal understanding and explanation of density which pupils meet in high school.

Because most scientific ideas undergo such gradual development, it is not possible to define core science simply by listing ideas or concepts that will be grasped. Rather it is a matter of trying to describe the stage of development that most pupils will have reached in the important ideas of science. This is what the maps of core science try to do: describing, not science itself, but an average pupil's understanding of it.

At the lowest level of understanding a pupil may acquire an idea merely as a string of words. For example, pupils often know the expression 'hot air rises' as a saying rather than as an understanding. At the other end of the scale a pupil may have incorporated an idea into his own frames of reference and so be able to make use of it in a wide range of circumstances. These widely different ways of knowing have been described as 'rote' and 'meaningful' respectively.

Core science is directed towards meaningful grasp of important scientific ideas and this arises from pupils' own practical investigations. Science specialists will want to guide and support their colleagues to ensure that they appreciate the important role played by practical investigation in developing pupils' understanding.


LET'S WALK UP TO WOOLIES, AND LOOK AT THE TOYS
IT'S A LOT OF FUN EVEN IF YOU CAN'T BUY ANYTHING
LOOK HERE... LOOK AT ALL THE LITTLE CARS!
!
?
ALL I CAN SEE IS THE FRONT OF THE COUNTER!
AND LOOK OVER HERE AT THE TINY ANIMALS!
I MUST SAY THEY'RE PUTTING GOOD WOOD INTO THEM THESE DAYS
GOSH... AND LOOK OVER HERE!
NICE AND SMOOTH, TOO; GOOD JOB OF SANDING
AND LOOK AT THE PAPER DOLLS, AND LOOK AT THESE TOY BOATS!
I SEE THEY USED SCREWS INSTEAD OF NAILS... THAT'S A GOOD IDEA
HERE ARE SOME TINY AIRPLANES AND THERE'S A TINY FIRE-ENGINE!
WE'LL HAVE TO DO THAT AGAIN SOMEDAY,
SURE... CALL FOR ME AGAIN IN ABOUT FOUR YEARS!

BEST COPY AVAILABLE

A knowledge of pupils' conceptual development suggests that the majority of pupils under the age of thirteen need concrete experience to enable them to grasp ideas. Pupils begin to cope with abstract ideas during middle schooling and some pupils acquire the ability to think formally, without concrete experience, to a considerable degree. However, the proportion of these pupils in most schools is small. Consequently, one major criterion in the selection of core scientific ideas is that they should be directly related to practical experience and this rules out many of the ideas explaining how things happen the way they do. Core ideas are generally concerned with the characteristics and behaviour of living things, objects and materials, rather than with explanations.

Certain important ideas cannot be gained from practical experience. In particular there are two areas of science where opportunities for practical investigation are very limited, namely 'Reproduction' and 'The Earth in the Universe'. In these areas pupils will develop ideas with the help of audio-visual aids. These will also be needed to supplement first-hand experience of animals and plants in developing ideas set out in the maps of 'Growth' and 'Variety and Adaptation'.

Certain other ideas, such as the fact that we measure forces in units called 'newtons', are of a different character from the majority of core ideas in that they are not to be derived from experience. There are very few of these but they can only be conveyed by verbal teaching.

3. CORE SCIENCE WITHIN THE WHOLE CURRICULUM

3.1 Links with other areas of the curriculum

Science supports and complements other subject areas within the curriculum. This is equally true when it takes the form of a timetabled subject and when it takes the form of science as a way of working across the curriculum.

(a) Links arising from common ways of working

Most of the ways of working used in scientific investigations are shared with other subject areas. The concern for careful observation is one which science shares with Art. Sometimes scientific investigations involve the prior setting up of experiments from which observations are made; very often observations are made directly and pupils are encouraged to examine the appearance and the behaviour of materials and of living things in their surroundings. Science shares with both Art and Mathematics, an interest in the regular visual patterns we find in the physical world, and science teachers, like their Art-teacher colleagues, design activities which encourage pupils to use and develop their senses so as to become more acutely aware of their surroundings.

Scientific investigations often take observation further, into the realms of sorting into sets, counting, calculation, and measurement. This involves trying to be more precise in describing observations and seeking those patterns which only emerge when we record observations and measurements, perhaps over a period of time as in the growth of a shoot or the stretching of a spring. Concern with number, sets and measurement and with the non-visual patterns which emerge from them is shared with Mathematics.

The raising of questions and planning of observations which form the start of any scientific investigation present pupils with incentive to thoughtful talking and writing. They are encouraged to make written records of their experiments and observations and to express the generalisations or patterns which emerge from their work. Pupils are encouraged to try to explain their observations and generalisations and to present their work and their ideas to others, either by talking or by writing. These processes of expressing and justifying ideas, describing and recording are all part of the process of scientific investigation and they are concerns which science teachers share with their English teacher colleagues. The small group discussion which accompanies most of pupils' science work presents excellent opportunities for language development, especially for those who need both practical things to talk about, and the small group atmosphere to give them confidence.

The investigatory approach to science tries to give pupils a sense of engaging in real inquiry and in practical problems. It is important for pupils not simply to be told that science is useful but to use it themselves in solving problems and making useful things. This aspect of science accords with the design-technology component of craft subjects and there are many opportunities for joint projects in which craft and science subjects combine in design and testing.

(b) Links arising from common content

Of course, links between areas of the curriculum often arise from shared subject matter and the core of the science curriculum provides for many such links. The main connections are between the following areas of the curriculum and their corresponding areas of science:

Health Education	Reproduction *(3)* Microscopic living things
Home Economics..	Food and feeding *(4)* Microscopic living things Materials
Craft and design	Materials
Music	Sound
Art	Light and colour
Geography	Rocks and minerals
Humanities	The earth in the universe Sensitivity

---

(3) In the case of work on reproduction, science is concerned with reproduction and the development of young in all living things, both animal and plant. Human reproduction takes its place in this context. Each school will develop its own policy for sex education and for the contribution to be made by the science teacher, but the core of the science curriculum includes those important scientific ideas about human reproduction which would form the basis of the science component.

(4) In the case of work on food and feeding, science is concerned with feeding as a characteristic process of all living things, both animal and plant, rather than with human food and nutrition in particular.

(c) Links made in integrated topics

Science has a very significant part to play in topic work. Although the description of the core of science deals separately with seventeen areas, these are no more than arbitrary, yet convenient, subdivisions of science. They do not require teaching programmes to be designed under the same headings. The core of the science curriculum can therefore be related to broad integrated topics. Some of the main connections between topics and areas of science are the following:

Houses and homes	Materials Light and Colour Electricity Water Movement, Forces and Structures Heat
Clothes and Costume ..	Materials Water
Ourselves	Sensitivity Growth Sound Light and Colour
Boats	Materials Water
Growing plants	Variety and Adaptation Reproduction Growth
Exploring the environment around school ..	Variety and Adaptation Materials Rocks and Minerals Movement, Forces and Structures
Weather	Air and other Gases Water Heat

3.2 Teachers' involvement in teaching core science

Scientific skills and ideas develop in topic work as well as in science lessons and many of them are within the reach of the younger pupils in middle schools. Therefore a very significant contribution to the core of science can be made by the teachers of younger pupils and by those who do not consider themselves to be science teachers.

The following maps help the teacher who is not a specialist in science to see which important skills and ideas can be derived from pupils' investigations. They are intended to be used under the guidance of the science specialist who will stress to his colleagues that the scientific ideas set out in the maps are to be fostered in practical investigation. *Science teachers will want to ensure that their colleagues devote careful attention to the scientific ways of working which are described on each map and that they do not resort to verbal teaching of ideas.*

3.3 Time allocation

If the core had been defined as a core syllabus of activities for pupils then it would have been possible to calculate the time needed for them and conversely the time remaining for teachers' and pupils' chosen interests and approaches. But, since the core has been defined in terms of the likely outcomes of teachers' own chosen approaches, the amount of time needed to fulfil the core intentions will perhaps vary from school to school.

When emphasis is placed upon pupils' own investigations, and when work takes the form of integrated topics linking areas of science or different aspects of the curriculum, it is impossible to be precise about the time needed to acquire particular skills and ideas. Any one activity for pupils contributes to the development of many skills and a number of scientific ideas. Conversely, for a pupil to refine a skill or to reinforce an idea several supporting and related activities are needed. For example, when pupils investigate melting ice and boiling water they use most of the scientific ways of working listed on page 5 and they meet many ideas about heat, about the three states of matter, about water, and about air. But none of these will be perfected from the one investigation: many other activities will be needed to develop the skills and to confirm the ideas. If pupils are working on a very broad topic such as boats or clothes then it becomes even harder to relate time to intentions.

The teachers who worked to define the core were acutely aware of the importance of selecting a modest core which could arise from unhurried, uninhibited investigations over the four years of middle school.

They made two assumptions:

(a) that schools would probably allocate at least the equivalent of two 35-minute periods per week to scientific activities in years 1 and 2, and at least the equivalent of four such periods per week in years 3 and 4;

(b) that a considerable contribution to the development of core skills and ideas would be made by work in the earlier years of middle schooling, probably directed by teachers who are not scientists but who would be guided by a science specialist.

Core science emphasises techniques of investigation and it aims for the kind of understanding which pupils can only gain from ample opportunity to talk and think about their investigations. These approaches, although time-consuming, are essential if science is to make its proper contribution to the curriculum and unfortunately they are usually the first casualties when time is short.

3.4 Continuity and Liaison

The core skills and ideas described in the maps of areas of science are those which teachers believe the majority of pupils are likely to develop by the time they are thirteen.

A significant proportion of these, particularly in areas like Sensitivity and Sound are likely to have been developed by many pupils before they reach middle school. Certainly pupils are likely to have

made progress in skills of questioning, observing, measuring and recording in their primary schools. A very large proportion of core scientific ideas and the majority of the core ways of investigating in each area of science are appropriate to the early years of middle schooling.

One of the important roles of a science specialist is to ensure continuity in the development of skills and ideas throughout the four-year curriculum and the maps can be used as a check-list in this context.

A major purpose of the maps is to convey to high school science teachers a clear and detailed description of the skills and ideas they can assume in the planning of courses for their first-year pupils. Maps have been carefully worded so as to try to convey the level of skill and understanding likely to be gained by the majority of pupils. Readers must, of course, be on their guard against misinterpreting the maps by reading more into the descriptions than is actually given.

Liaison meetings between middle school and high school science teachers will be able to draw upon the maps as a basis for detailed discussion. Indeed, in due course it may be possible to revise and improve the description of core science in the light of further shared experience.

4. A DESCRIPTION OF CORE SCIENCE

4.1 Introduction to the maps of core science

1. Core science presents pupils with a mental map to help them investigate and find their way around the subject. It is presented in seventeen sections or separate maps:

(1) The Earth in the Universe

(2) Variety and Adaptation

(3) Reproduction

(4) Growth

(5) Food and Feeding

(6) Sensitivity

(7) Miscroscopic Living Things

(8) Movement, Forces and Structures

(9) Heat

(10) Light and Colour

(11) Sound

(12) Magnets and Magnetism

(13) Electricity

(14) Water and Other Liquids

(15) Air and Other Gases

(16) Materials

(17) Rocks and Minerals

2. Taken together, these seventeen maps draw upon the whole span of the physical world. Core science amounts, therefore, to a balanced and comprehensive introduction to the physical environment - the 'map without bits missing' described on pages 1 and 2.

3. This sub-division is entirely for convenience of reference and it does not presuppose that teachers will plan teaching programmes within these themes. There are many points of connection and overlap between materials, forms of energy and living things; thus teaching topics will often contribute to the core of a number of areas of science.

4. The format of each map

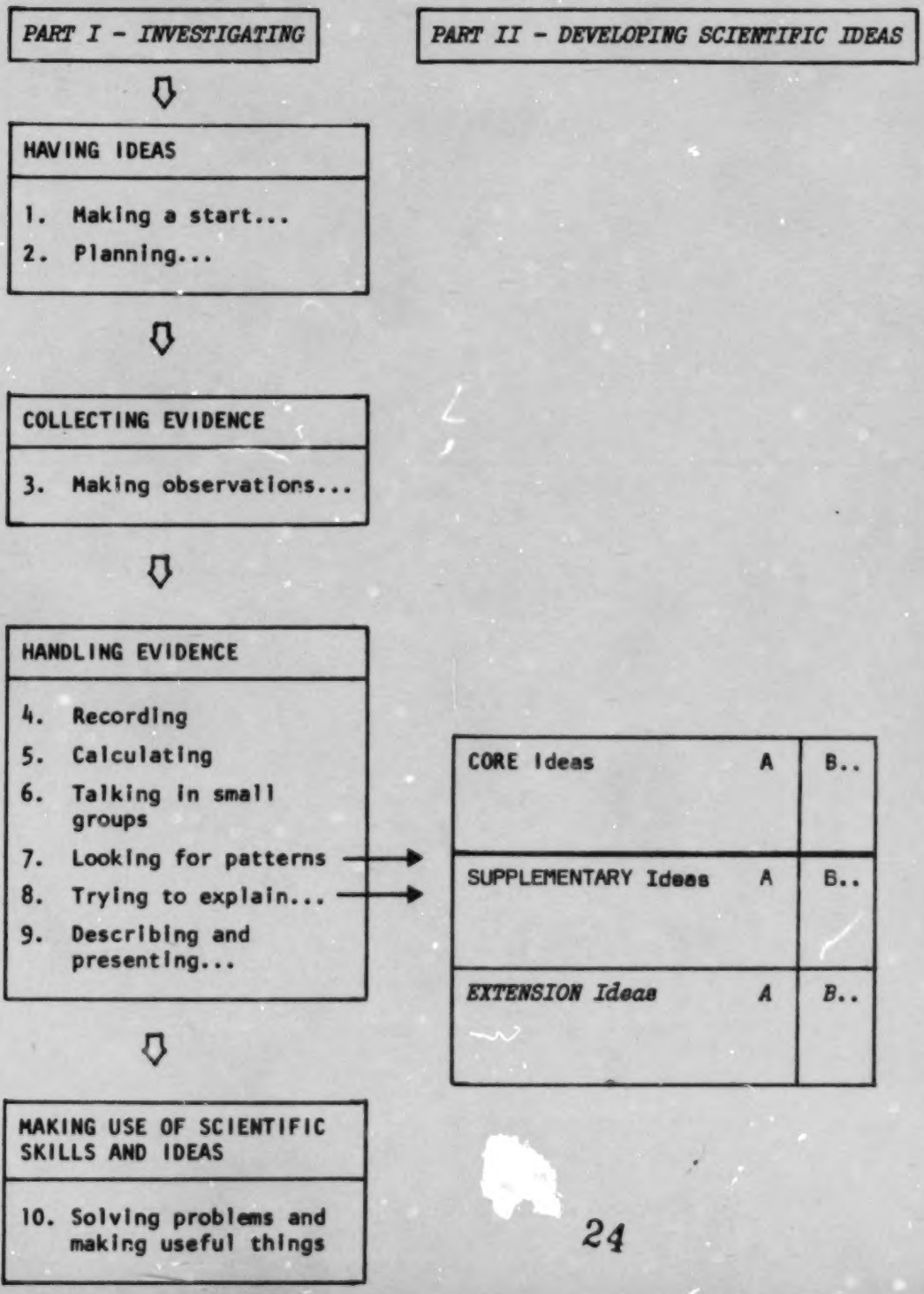
Each map is made up of two parts and a sample scheme of work:

(i) Part 1 describes scientific ways of working and investigating

(ii) Part 2 describes scientific ideas which develop

(iii) The Sample Scheme of Work lists a variety of activities for pupils to show ways in which core skills and core scientific ideas might be developed.

The diagram below shows the connection between Part 1 and Part 2. Core ideas are the important patterns which pupils find in their investigations.



The sequence of techniques for investigating applies to all areas of science with the exception of 'The Earth in the Universe' and the part of 'Reproduction' which is concerned with animals where the majority of scientific ideas are developed from audio-visual aids and by verbal teaching.

(I) PART 1 of each map describes core investigation techniques in detail with specific reference to that area of science. Examples are given of the kind of question or idea which can start an investigation, of the kind of experiment planning to be done, of the kind of causal explanations pupils might give, and of problems which might be tackled.

For the collecting of evidence, recording, calculating and looking for patterns, a complete list of core techniques is given.

(II) PART 2 of each map describes developing scientific ideas in three categories:

(a) Core ideas are the important scientific ideas which the majority of pupils can grasp by the age of thirteen.

(b) Supplementary ideas, although no more difficult than core ideas, are not important enough to form part of the core.

(c) Extension ideas are more difficult, abstract ideas which may be understood by pupils who have reached a later stage of conceptual development.

Core ideas

Core ideas have been worded very carefully in an attempt to describe the level of understanding which most pupils are likely to have reached. Consequently they do not always represent what a high school teacher would accept as accurate science.
They are not descriptions of science but attempts to express the kind of understanding which the average pupil can achieve by the age of thirteen.

Core ideas are usually patterns or generalisations which can be drawn from concrete, practical activities. The majority of middle school pupils are believed to be at a stage of conceptual development in which they need concrete experience from which to grasp ideas.

Core ideas could not therefore include abstract ideas calling for formal thinking, even though these are within the grasp of a number of pupils and perhaps a significant number in some schools.

Core ideas are selected because they are both important and within the reach of most pupils. In very rare cases a more difficult idea is so important that it is included as a core idea even though pupils are expected to gain no more than a bare acquaintance with it. They are likely to hold such an idea

rather at a rote than a meaningful level of understanding. The idea of air pressing in all directions making up atmospheric pressure is one of these. They are marked ● to remind high school teachers that here is an idea which middle school colleagues will introduce in the hope of taking a step towards understanding, but one which they do not expect to have much meaning for pupils.

Many core ideas appear on more than one map. These ideas have the other map references indicated in brackets.

Supplementary and Extension Ideas

Supplementary and extension ideas have been included on each map in order that core ideas can be seen in context. Very often comparison of core and extension ideas will help the reader to see what is and what is not to be expected of the average thirteen-year-old. Many supplementary ideas relate to individual examples which contribute to the broad 'pattern' ideas of core.

(iii) The SAMPLE SCHEME OF WORK for each map lists, with references, a variety of activities for pupils which teachers may like to consider when they are preparing their own approaches to core science. Activities are listed by reference to the most widely-used, published curriculum materials, in particular 'Science 5/13' and 'Nuffield Combined Science'. They are activities which emphasise practical investigation and also lead to core scientific ideas.

Teachers will, of course, select their own programme of activities for fulfilling the intentions of core science and the sample scheme relating to each map is in no sense a core syllabus of recommended activities.

5. Use of the Maps

Teachers who work with pupils in the 9/13 age group can use the maps either as a check-list after completing a programme of work and as a guide to selecting activities for pupils.

Teachers who do not consider themselves to be specialist teachers of science will find in the maps detailed guidance on the purpose of scientific activities for pupils, whether these are science-based or contributing to broader topics.

Teachers who plan courses for the first year of high school will find in the maps a detailed description of what can and what cannot be expected of the majority of thirteen-year-old pupils.

4.2 Maps for investigating and developing ideas about:

(1) The Earth in the Universe

(2) Variety and Adaptation

(3) Reproduction

(4) Growth

(5) Food and Feeding

(6) Sensitivity

(7) Microscopic Living Things

(8) Movement, Forces and Structures

(9) Heat

(10) Light and Colour

(11) Sound

(12) Magnets and Magnetism

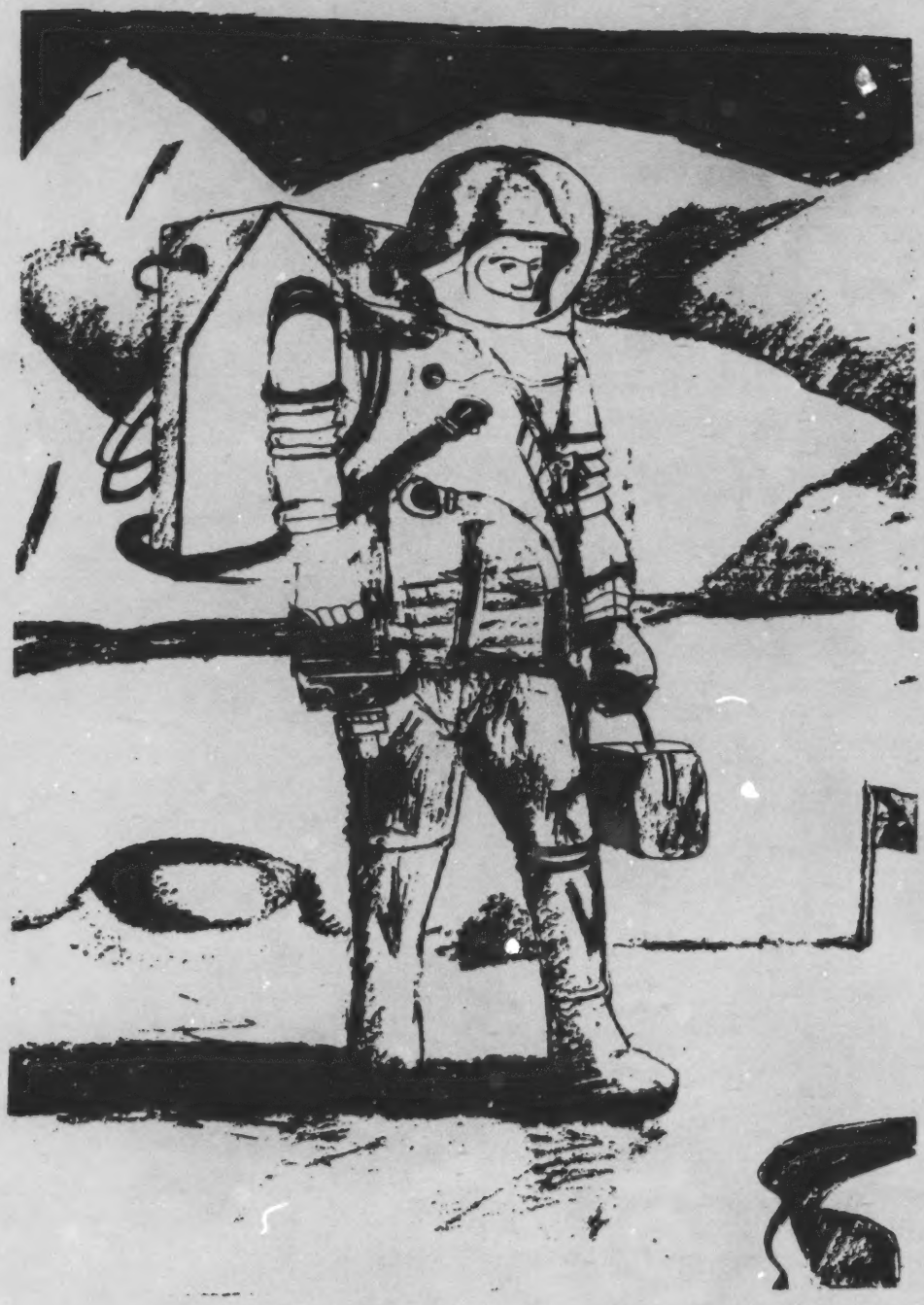
(13) Electricity

(14) Water and Other Liquids

(15) Air and Other Gases

(16) Materials

(17) Rocks and Minerals



Illustrations presented with these maps are the work of pupils in Middle Schools.

- Pupils usually develop scientific ideas by working like scientists on practical investigations but this area of science is unusual in having few practical investigations which pupils can do. Therefore, in working on the earth and its place in the universe, pupils will not be able to use the processes of scientific investigation which form part of the core of most other areas of science. Instead they will be involved in discussions, and in learning from books and audio-visual aids. Certain practical investigations can be made upon shadows, the positions of the sun, the phases of the moon and the night sky.

- This theme provides especially good opportunities for speculative talking and writing, and the fascination of the ideas seems to make up for their difficulty.

DEVELOPING SCIENTIFIC IDEAS

CORE ideas are important scientific ideas which the majority of pupils can grasp, by the age of thirteen, in the form expressed here.

Because most of the ideas in this theme are so abstract and hard to grasp, there are few core ideas and these are limited to Sections C, D and E.

However, there remains the basic intention to use whatever ideas are interesting to pupils in order to let them engage in speculation about the universe and about man's place in it.

SUPPLEMENTARY ideas present some of the notions which pupils may begin to explore.

EXTENSION ideas are even more difficult ideas which may be interesting to pupils who have reached a later stage of conceptual development.

A THE UNIVERSE

A1 'The universe' means everything everywhere.

A2 The universe is so big that we have to struggle to imagine it.

A3 There are millions of galaxies in the universe and each galaxy is made up of millions of stars.

A4 There are many things that we still do not know about the universe. From man's exploration of space and from experiments we are learning more.

A5 The name of the galaxy which includes the earth is the 'Milky Way'.

A6 It has been suggested that there are more stars in the universe than there are grains of sand on all the beaches of the world!

A7 We cannot be sure how the universe was formed, but there are several different ideas.

A8 The universe is slowly but constantly changing.

A9 We are not sure whether the universe has an end or whether it goes on infinitely in space.

B SUNS AND STARS

B1 Every star is a sun, similar to our sun.

B2 A star is an enormous mass of very hot material which gives out heat and light.

B3 Our sun is enormous compared with the earth but very small compared with some of the other suns/stars.

B4 Because stars are so much further away from us than our sun is, they seem smaller.

B5 Planets move around the sun and we call a planet's path an 'orbit'.

B6 Our sun has nine planets, and one of them is the earth.

B7 Our sun with its planets is called 'the solar system'.

B8 The nearest star, apart from the sun is Proxima Centauri.

B9 Proxima Centauri is 4.3 light years away.

B10 New stars are being formed all the time.

B11 Because stars are so much further away from us than our sun is, we do not feel their heat.

B12 Because stars are so much further away from us than our sun is, we get less light from them.

B13 Other stars/suns probably have planets travelling around them.

B14 The sun is so big that it could contain more than one million earths!

B15 Stars appear to form patterns, or 'constellations', in the night sky. Men have given names to some of these patterns.

B16 People in the southern hemisphere see a different set of stars from those we see in the Northern hemisphere.

B17 Some of the stars we see no longer exist: the light we see set out from them long ago and they have since burnt out.

B18 Stars in a constellation appear to be the same distance from us, but in fact they usually differ in their distance away from the earth.

B19 Planets are kept in their orbits by the pull of the sun's gravity.

C	LIGHT IN THE UNIVERSE	D	MOON
C1	Light comes only from stars/suns. Planets do not give out light. * (Light and Colour G1)	D1	The moon travels round the earth. We say that the moon is the earth's 'satellite'. *
		D2	The moon is our nearest neighbour in space. It is the first part of the universe to which man has travelled. *
		D3	The moon does not have light of its own: it reflects the sun's light. *
		D4	The moon has a pulling force which we call 'gravity'. The moon's gravity is less than that of the earth. * (Movement, Forces and Structures B2)
C2	Light travels much faster than anything else we know. (Light travels at: 300,000,000 metres per second 186,000 miles per second).	D5	The bright part of the moon changes shape, and returns to full moon every 28 days.
C3	Even though light travels so very fast, it takes a long time, even many thousands of years, to travel to us from stars.	D6	The moon turns on its own axis once every 28 days.
		D7	The moon always has its same side facing the earth.
C4	Stars are so very far away that we measure their distance away in 'light-years'. The distance that light travels in one year is called a 'light-year'.	D8	The moon has no air surrounding it.
C5	It takes eight minutes for light to reach the earth from the sun.		
C6	*Scientists believe that nothing could travel faster than light.*	*D9*	*The moon seems to change shape as the sun shines on it from different directions.*
C7	*The light from the faintest stars that we now see set out about 5,000 million years ago.*	*D10*	*When the earth comes between the moon and the sun, we see the earth's shadow on the moon. It is called an 'eclipse' of the moon.*
		D11	*The moon is a silent place because there is no air to carry sound.*
		D12	*When the moon comes between the earth and the sun part of the sun's light is cut out and we have an 'eclipse' of the sun.*
		D13	*The moon always has its same side facing the earth because it spins on its axis in the same time as it takes to revolve around the earth.*
		D14	*Because the moon is much smaller than the earth its gravity is less.*

E EARTH

E1 The earth existed for a long time before man evolved. *

E2 The earth is warmed by heat from the sun. Without the heat and light of the sun there could be no life on earth. *
(Light and Colour G1) (Heat F6)

E3 Living things can only exist where the temperature is suitable, where the air is suitable and where there is food. *

E4 The earth makes a spin on its axis once every 24 hours. *

E5 We have daylight when our side of the earth is facing the sun, and we have darkness when our side of the earth has moved away from the sun.

E6 The earth has a pulling force which we called 'gravity'.
(Movement, Forces and Structures B2)

E7 The pull of the earth is what gives an object its weight. *
(Movement, Forces and Structures B3)

E8 The layer of air around the earth is called the 'atmosphere'.

E9 If man leaves the earth to travel to the moon or to another planet he needs to take a life support system with Him.

E10 The earth's atmosphere acts as a filter which shields us from harmful rays that come from space.

E11 Conditions suitable for life almost certainly exist in other places in the universe.

E12 The size of a planet and its distance from the sun affect the conditions of the planet.

E13 The seasons occur because sometimes the earth's axis tilts towards the sun (summer) and sometimes away from the sun (winter). At other times (spring and autumn) it tilts neither towards nor away from the sun.

F COMETS AND METEORS

F1 A meteor is a piece of rock in space.

F2 When meteors enter the layer of air around our earth they burn up and we see them as shooting stars.

F3 Meteors are pulled towards larger objects like planets.

F4 If a meteor is too large to burn up completely as it falls, it reaches the earth as a 'meteorite'.

F5 Until we sent space ships into space meteors were our only source of material from anywhere outside the earth.

F6 Meteors burn up in our atmosphere because friction with the air as they fall makes them very hot.

F7 Comets consist of gases which have frozen.

F8 As a comet passes near the sun, the sun's heat changes the outer layers of comet into a vapour which we see as a 'head' and a trailing 'tail' of the comet.

There are few opportunities for practical investigation in this area of science. These are listed below, together with references, as suggestions for teachers to consider in preparing an approach to this theme.

Activity	Reference o	Skills Used *	Ideas Developing *	Year	*Minimum* Time Needed
Following the sun, or a shadow, throughout the day; making a simple shadow clock	Science 5/13, Early Experiences, pages 4 - 10	1,3,4,6,7, 8,9,10	E4	1 or 2	Short periods during a sunny day plus ½ hour for development
Recording the shape of the moon over one month	Science 5/13, Early Experiences, page 15 Science 5/13, Time, page 40	1,3,4,7,8, 9	D1,D5,D6	1 or 2	Homework over 1 month
Making a shadow clock	Science 5/13, Time, pages 9 - 13	1,2,3,4,6, 7,8,9,10	E4,E5	2 or 3	½ hour plus short periods during a sunny day plus 1 hour for development
Feeling the pull of the earth	Nuffield Combined Science Teachers' Guide I, pages 146 - 149	3,4,6,7,8, 9	E6,E7	3	Within an investigation into forces, overlapping with work on movement, forces and structures
Discussion, with audio-visual aids, about the earth, other planets and the stars of the universe, including attempts to explain the experiences of earlier work ‡	Science 5/13, Time, pages 36 - 42 New Unesco Source Book for Science Teaching, Sections 4.65 - 4.98	1,6,9	-	4	2 hours

‡ Audio-visual aids and references for pupils

There are many publications which teachers will find helpful, including:

Ryan and Pesek, Journey to the Planets, Penguin, 1972

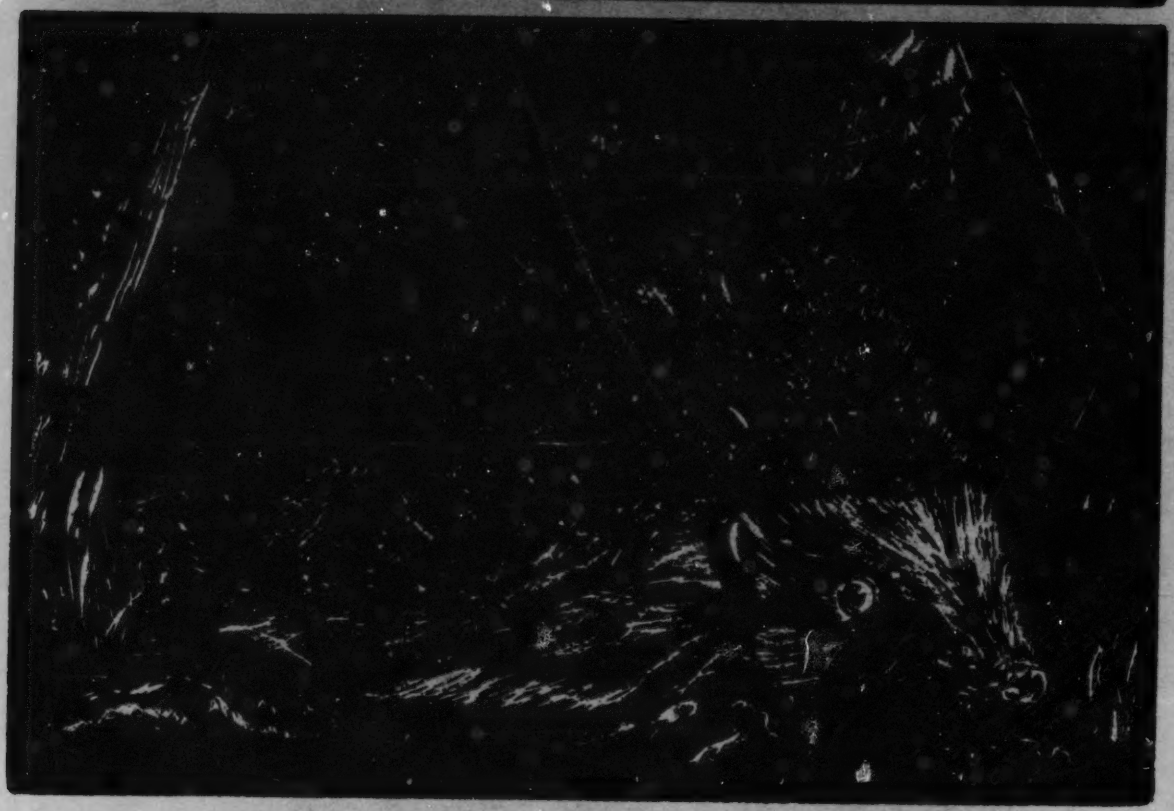
Geological Museum, The Story of the Earth, H.M.S.O. 1972

Helios planeterium : available on loan from the John Taylor Teachers' Centre

o Details of references are given in Appendix 1

* Skills are listed by number with reference the sequence of investigation techniques at the beginning of all other maps.

Ideas are listed by section and number with reference to the preceding pages.



☐ Pupils develop scientific ideas about variety and adaptation by working like scientists on practical investigations.

☐ A practical science activity for pupils will usually give them the opportunity to work through the sequence of investigation techniques and to begin to develop scientific ideas.

☐ CORE SCIENCE is made up of both the techniques of investigating described below, and the emerging ideas which follow.

CORE SCIENCE STARTS HERE

⇩

PART I - INVESTIGATING

⇩

HAVING IDEAS

1. Making a start

   (a) Asking questions which can be answered by observing or experimenting

   For example, 'Do feathers keep birds warm?' or 'Does fur keep mammals warm?'

   or (b) Expressing ideas which can be put to the test

   For example, 'Animals huddling together keep warm'.

2. Planning observations, fair tests or controlled experiments, in small group discussion, individually or in a whole class

   For example, planning an experiment to investigate the growth of seeds in a variety of different environments.

⇩

COLLECTING EVIDENCE

3. Making observations, either directly or from experiments, and measuring when it is appropriate

   Children will be meeting a wide variety of living things, including examples of mammals, birds, insects, fish, reptiles, worms, spiders, amphibians, micro-organisms, flowering plants, deciduous and evergreen trees, mosses, ferns and seaweeds. Audio-visual aids may be needed for some of these. Pupils will be:

   (a) observing similarities and differences among plants and animals, both in appearance and behaviour, using lenses, magnifiers and microscopes when these are helpful;

   (b) measuring temperatures both in the environment and in experimental equipment;

   (c) measuring the size of animals, plants, eggs or seeds in terms of length, height, or weight;

   (d) counting numbers of individuals in surveys of habitats.

HANDLING EVIDENCE

4. Recording
   (a) making drawings, from real specimens, of animals and plants;
   (b) using tables to show numbers of species in habitats;
   (c) using bar-graphs to show variations in size within a group or in populations within a habitat. (Teachers' help in selecting the best scale will often be needed).

5. Calculating
   There are many calculations which children can make from their measurements but none which is a core skill within this theme.

6. Talking in small groups or as a whole class, children will explore and develop their own ideas about their experiences.

7. Trying to classify, order and look for patterns
   Children will put animals and plants into groups according to the similarities and differences which they find. Pupils will develop from grouping by habitat towards grouping by characteristics.
   (The patterns which pupils will see in their observations follow as scientific ideas). →

8. Trying to explain in terms of cause and effect
   For example, 'Plants do not grow well on walls because there is little soil or water'.
   (Explanations of a more sophisticated kind follow as extension ideas). →

9. Describing and presenting evidence and ideas
   Children will prepare drawings, tables and bar-graphs and they will be talking and writing in their own words.

⇩

MAKING USE OF SCIENTIFIC SKILLS AND IDEAS

10. Solving problems and making useful things
    For example, 'Providing the best conditions for a seed to germinate'.

PART II - DEVELOPING SCIENTIFIC IDEAS

	A PUTTING ANIMALS AND PLANTS INTO SETS
CORE ideas are important scientific ideas which the majority of pupils can grasp, by the age of thirteen, in the form in which they are expressed here. They try to show the point reached by the majority of 13-year-olds on their journey towards understanding more formal scientific ideas. Most of the core ideas are patterns which pupils will see in their own practical activities, but there are some which cannot be presented practically and which therefore need verbal or audio-visual teaching; these are indicated by *. ● indicates ideas which pupils have difficulty in grasping but which are so important that they are attempted in the middle years.	A1 Living things are either animals or plants. A2 Animals or plants are grouped together in sets because they have important similarities.
SUPPLEMENTARY ideas are no more difficult than core ideas, but they are less important.	A3 Animals or plants of one kind differ slightly from one another, in height or weight or colour for example. A4 Animals and plants which resemble one another are grouped into sets because there are so many different animals and plants that it is helpful to sort them out.
EXTENSION ideas are more difficult, abstract ideas which may be understood by pupils who have reached a later stage of conceptual development, characterised by abstract thinking.	*A5 A key can be used to identify an animal or plant when we have a specimen to examine.* *A6 A key asks questions which help you to put your unknown animal or plant into a set and then a sub-set, and so on, until you can identify it.*

B HOW DO PLANTS VARY?

(In order to recognise the similarities and differences which allow us to group plants into sets such as mosses, ferns, flowering plants, children will meet a wide variety of plants. They will begin to look for ways in which plants are fitted to their environments and to notice plants' preferences for particular habitats.)

B1 Plants vary in size, shape, appearance and way of life.

B2 Plants of any one kind are not identical but they vary in small ways, in exact size for example.

B3 Most of the plants we notice have roots, stems, leaves and flowers.

B4 A tree is a very big plant.

B5 Some trees are called 'evergreens' since they carry leaves all the year round. Leaves are shed by evergreen trees throughout the year but never all at one time. Other trees lose all their leaves each autumn.

B6 There are very small plants which you need a microscope to see and others as big as the giant red wood trees.

B7 Some roots are food stores for the plant.

B8 Some stems creep along the ground. Others may climb by twisting or clinging onto things.

B9 Leaves have veins which may be parallel or branched.

B10 Different kinds of plants have their leaves arranged on the stem in different ways.

B11 Trees which lose their leaves each autumn are called 'deciduous' trees.

B12 The reason for the great variety of plants and animals is that each is specially fitted for living in one of a wide variety of places.

B13 There are groups of plants which do not have flowers. They include mosses, ferns, algae and fungi.

C ANIMALS LIVING IN HOT CLIMATES

C1 Animals cannot live in a very hot place unless they are adapted in some way. Animals which live in hot climates have special features or ways of living which help them to cope with the heat.

C2 Most mammals lose heat by sweating.

C3 Mammals which lack sweat glands lose heat by panting.

C4 Cold blooded animals cope with hot climates more easily than warm blooded animals.

C5 The main problems of land animals in hot climates are overheating and drying out.

C6 Animals which live in hot climates have special adaptations to prevent loss of water.

D HOW DO ANIMALS VARY?

(In order to recognise the similarities and differences which allow us to group animals into sets such as mammals, birds, insects, fish, reptiles, children will meet a wide variety of animals. They will begin to look for ways in which animals are fitted to their environment.)

D1 Animals vary in size, appearance and way of life.

D2 Animals of any one kind are not identical but they vary in small ways, in exact size for example.

D3 The largest animals alive today are the African elephant on land and the blue whale in the sea.

D4 There are many kinds of animal without a backbone such as jelly-fish, worms, snails, insects and spiders.

D5 Fish have scales and fins. They lay many small eggs.

D6 Amphibians have soft damp skins but no scales. They lay eggs covered in jelly.

D7 Reptiles have scales but no fins. They lay soft-shelled eggs.

D8 Birds have feathers, beaks and wings. They lay hard-shelled eggs.

D9 Mammals have fur or hair and feed their young on milk, their young are born looking like the parents.

D10 Man is a member of the set of mammals.

D11 There are two main sets of animals: vertebrates which have an internal skeleton or 'backbone' and invertebrates which do not.

D12 The set of animals with a backbone is made up of fish, amphibians, reptiles, birds and mammals.

D13 Animals without a backbone are not usually as large as animals with a backbone.

D14 A cold-blooded animal has a body temperature the same as that of the outside and its temperature changes with the outside temperature.

D15 A warm-blooded animal is one which keeps a steady body temperature whatever the outside temperature.

D16 Scientists have bred animals with particular features. (Examples are horses for racing or for pulling carts; cows for milk; pedigree dogs for show; hens for eggs; animals for meat; pack mules for carrying weights).

E PLANTS LIVING IN DIFFERENT PLACES

E1 Different kinds of plant grow in different places: each kind grows where the conditions are best suited to it.

E2 Plants which live in dry or cold places have small needle-like leaves, or leaves which are covered in hairs or in wax.

E3 Plants which live in dry places have long roots.

E4 Plants which live in wet places have large leaves.

E5 Plants which live in dry places have small or waxy leaves which lose less water than other leaves.

E6 Plants which live in wet places have large leaves which lose more water than other leaves.

E7 In cold weather plants cannot easily get water through their roots and many die.

Those trees which do not have small or waxy leaves adapt to winter by losing their leaves.

F	ANIMALS LIVING IN COLD CLIMATES	G	SURVIVAL
F1	Animals cannot live in a very cold place unless they are adapted in some way. Animals which live in cold climates have special features or ways of living which help them to cope with the cold.	G1	Animals spend nearly all their time fighting for survival: searching for food and water and avoiding predators.
F2	Birds and mammals are most successful at coping with cold.	G2	Plants are constantly being nibbled by animals and they are constantly growing to repair themselves.
F3	Some animals adapt to cold by hibernating.		
F4	Mammals and birds can fluff out their fur or feathers to keep them warm. Some mammals and birds have adapted to extreme cold by developing thicker fur or feathers.		
F5	Some animals store stocks of food to last through the winter.		
F6	Many animals store fat or blubber under their skin and this helps to keep them warm.		
F7	Some animals migrate to a warmer climate when it becomes colder.		
F8	Some animals have big feet which prevent them from sinking into snow.		
F9	Some animals grow a white coat of fur or feathers in the winter and this acts as camouflage as well as keeping them warm.		
F10	In order to keep warm man makes use of fire and of insulating materials in clothes and houses.		
F11	Many kinds of animal huddle together in groups to keep warm.		
F12	We find the larger examples of certain kinds of animal in colder climates. For example, the larger kinds of penguin are found in the colder climates.		
F13	*The coldest seas are not so cold as the coldest land and while the sea stays liquid some cold blooded animals can survive in it.*	*G3*	*If it were not for the seeds or spores they produce, which can survive cold, heat or drought, plants would die out.*
F14	*Only warm-blooded animals cope with the coldest climates on land.*	*G4*	*Young plants are easily overcome by the activities of other living things living on or in them. Fully grown plants are more robust and they can withstand the activities of other living things.*
F15	*Air trapped in fur and feathers makes animals' coats warmer.*		
F16	*The surface area/volume ratio of an animal affects its loss of heat. Therefore, we usually find larger examples of species in colder climates.*		
F17	*Having only limited ability to adapt to his environment, man can survive in severe conditions only because he can adapt his immediate environment.*		

Activities for pupils are listed below, together with references, as suggestions for teachers to consider in preparing an approach to this theme. These activities can be taken together or they can be used individually within other topics as shown in Section 5.2. Most of them will also contribute to core skills and ideas on other maps.

Activity	Reference	Skills Used *	Ideas Developing *	Year	Minimum Time Needed
Looking for plants in different places	Science 5/13, Using the Environment 2 Investigations Part 1, pages 8 - 11 Science 5/13, Using the Environment 2 Investigations Part 1, pages 21 - 23 Science 5/13, Trees, page 62	1,2,3,4,5, 6,7,8,9	B1,B3,B4, E1	1 or 2	2 hours repeated at intervals throughout a year
Looking for changes in trees	Science 5/13, Using the Environment 2 Investigations Part 2, pages 42 - 44 Science 5/13, Trees, pages 13 - 18, 41, 51	1,3,4,6,7, 8,9	B1,B3,B5	1 or 2	1 hour repeated at intervals throughout a year
Looking for animals in different places	Science 5/13, Using the Environment 2 Investigations Part 1, pages 12 - 18 Science 5/13, Minibeasts, pages 11 - 27 Science 5/13, Using the Environment 2 Investigations Part 1, pages 20 - 21 and 24 - 29	1,2,3,4,6, 7,8,9	C1,D1	1 or 2	3 hours to begin to investigate a few different habitats
Observing birds	Science 5/13, Using the Environment 2 Investigations Part 2, pages 82 - 108	2,3,4,6,7, 9	D1	1 or 2	1 hour repeated at intervals throughout a year
Looking at small animals	Science 5/13, Minibeasts, pages 42 - 56	1,2,3,4,6, 7,8,9	D1	1 or 2	1 hour repeated at times when small animals are available
Sorting plants into sets	Biology for the Individual Book 1, page 56 Nuffield Combined Science Teachers' Guide 1, pages 14 - 17	3,6,7,9	A1,A2,B1	2 or 3	1½ hours
Identifying trees	Nuffield Combined Science Teachers' Guide 1, page 55 and Activities 1, pages 45 - 48	3,6,7,9	A2	3	½ hour
Sorting animals into sets	Biology for the Individual Book 1, pages 2 - 18 Nuffield Combined Science Teachers' Guide 1, pages 14 - 17	3,6,7,9	A1,A2	3	2 hours

/cont...

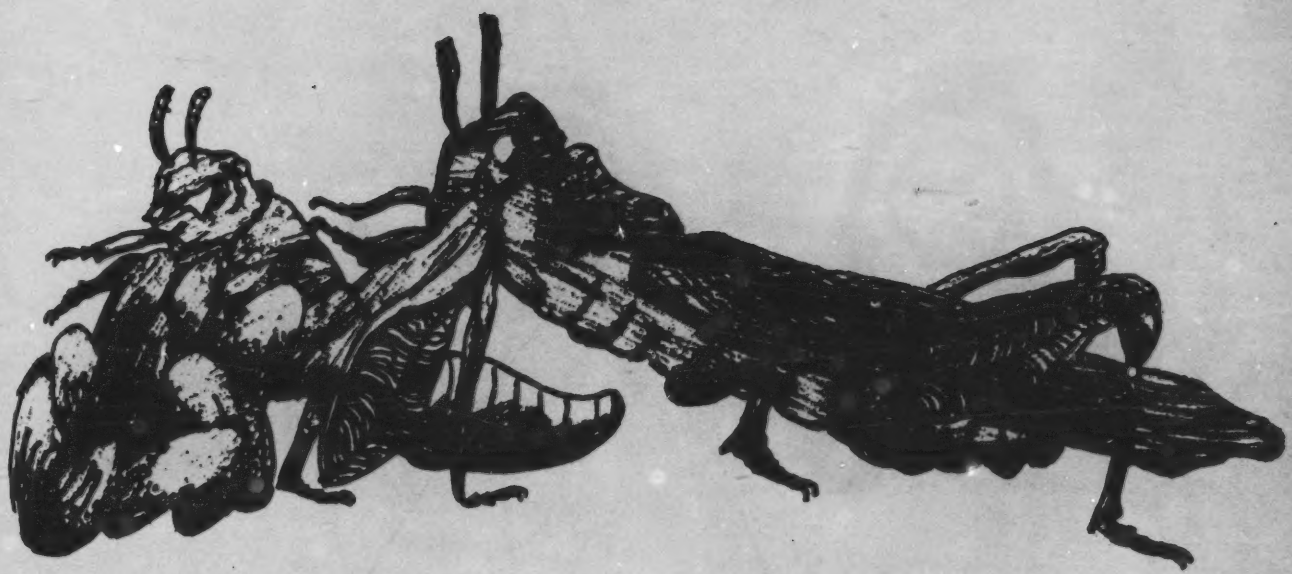
VARIETY AND ADAPTATION **2**

Activity	Reference o	Skills Used *	Ideas Developing *	Year	Minimum Time Needed
Looking at water animals	Nuffield Combined Science Teachers' Guide II, pages 5 - 7 and Activities 6, pages 10 - 12	3,4,6,7,8	A2,D1	3	1 hour
Finding small animals in compost or in soil	Nuffield Combined Science Teachers' Guide I, pages 50 - 52 and Activities 1, page 41	3,4,6,7,8	A2,D1	3	1 hour
Finding out about keeping warm and keeping cool	Biology for the Individual Book 5, pages 2 - 12 Nuffield Combined Science Teachers' Guide II, pages 36 - 42 and Activities 6, pages 42 - 43	1,2,3,4,5, 6,7,8,9, 10	C1,F1	4	2½ hours
Looking at variety in living things	Science 5/13, Using the Environment 3 Tackling Problems Book 1, pages 64 - 78	1,2,3,4,5, 6,7,8,9	B2,D2,E1	4	2 hours
Observing the dependence of living things upon one another	Science 5/13, Using the Environment 3 Tackling Problems Book 1, pages 9 - 30	1,2,3,4,6, 7,8,9	G1,G2,G3, G4	4	2 hours initially and several periods over a year

o Details of references are given in Appendix 1

* Skills are listed by number with reference to the sequence of investigation techniques at the beginning of this map.

Ideas are listed by section and number with reference to the preceding pages. An activity may simply contribute to the development of an idea or it may be designed specifically to teach a particular idea.



☐ Pupils usually develop scientific ideas by working like scientists on practical investigations. However, *animal reproduction* is an area of science learning in which scientific ideas are developed mainly from verbal teaching and from audio-visual aids.

☐ Practical activities relating to *plant reproduction* will usually give pupils the opportunity to work through the sequence of investigation techniques and to begin to develop scientific ideas.

☐ CORE SCIENCE is made up of <u>both</u> techniques of investigation <u>and</u> emerging ideas.

CORE SCIENCE STARTS HERE

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PART I - INVESTIGATING

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HAVING IDEAS

1. <u>Making a start</u>

   (a) <u>Asking questions which can be answered by observing or experimenting</u>

   For example, 'Can a leaf grow into a new plant?' or 'Do seeds grow better if they are planted a certain way up?'.

   or (b) <u>Expressing ideas which can be put to the test</u>

   For example, 'Perhaps each flower of one kind produces the same number of seeds'.

   (Questions and ideas are likely to be about seed germination rather than about reproduction itself).

2. <u>Planning observations, fair tests or controlled experiments, in small group discussion, individually or in a whole class</u>

   For example, planning an experiment to compare the number of seeds germinating from different packets, or from different plants.

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COLLECTING EVIDENCE

3. <u>Making observations, either directly or from experiments, and measuring when it is appropriate</u>

   (a) observing and measuring the germination and growth of a variety of seeds, from fruits which pupils have themselves gathered or brought to school;

   (b) observing a wide variety of flowers, looking for similarities and differences, using magnifiers or microscopes in search of details which cannot be seen with the naked eye;

   (c) observing, through audio-visual aids in many cases, a wide variety of animals and their young, looking for similarities and differences in ways of producing and rearing young.

HANDLING EVIDENCE

4. Recording

   (a) making drawings to record observations of plants and their seeds or of animals and their young;

   (b) using tables to record measurements.

5. Calculating

   There are many calculations which pupils can make from their measurements but none which is a core skill within this theme.

6. Talking in small groups or as a whole class, children will explore and develop their own ideas about their experiences.

7. Trying to classify, order and look for patterns

   (a) sorting flowers into sets according to how they are pollinated;

   (b) sorting fruits into sets according to how they are dispersed from the parent plant.

   (The patterns which pupils will see in their observations follow as scientific ideas). →

8. Trying to explain in terms of cause and effect

   For example, 'This dandelion is growing here because the wind blew a seed to this spot'.

   (Explanations of a more sophisticated kind follow as extension ideas). →

9. Describing and presenting evidence and ideas

   Children will prepare drawings, tables and bar-graphs and they will be talking and writing in their own words.

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MAKING USE OF SCIENTIFIC SKILLS AND IDEAS

10. Solving problems and making useful things

    For example, trying to prevent dispersal of the seeds of an unwanted weed.

PART II - DEVELOPING SCIENTIFIC IDEAS

CORE ideas are important scientific ideas which the majority of pupils can grasp, by the age of thirteen, in the form in which they are expressed here.

They try to show the point reached by the majority of 13-year-olds on their journey towards understanding more formal scientific ideas.

Most of the core ideas are patterns which pupils will see in their own practical activities, but this is a theme involving many ideas which cannot be presented practically and which therefore need verbal or audio-visual teaching- these are indicated by *.

● indicates ideas which pupils have difficulty in grasping but which are so important that they are attempted in the middle years.

SUPPLEMENTARY ideas are no more difficult than core ideas, but they are less important.

EXTENSION ideas are more difficult, abstract ideas which may be understood by pupils who have reached a later stage of conceptual development, characterised by abstract thinking.

A MALE AND FEMALE

(Most pupils are likely to understand the word 'cell' merely as a label for the smallest unit of life).

A1 Living things, both animals and plants, grow old and die. New animals and plants grow, replacing those which die.

A2 Animals and plants have special parts which produce male and female reproductive cells. *

A3 Male animals have testes where male cells, sperm, are made. *

A4 Female animals have ovaries where female cells, eggs, are made. *

A5 Most kinds of animal have males and females. We say that females are the 'female sex' and that male animals are the 'male sex'. *

A6 Different sexes in a kind of animal can often be distinguished by colour, shape and body size.

A7 Only mature males and mature females can produce young.

A8 The male animal is often brightly coloured and more impressive than the female.

A9 Some simple animals have both male and female parts in the same animal.

A10 Different types of animal have their own ways of reproducing which are especially fitted to their environment.

B MATING

B1 Most animals can reproduce themselves by the joining together of male and female cells. *

B2 The joining of a male cell and a female cell is called 'fertilization'. *

B3 When a male sperm cell joins with a female egg cell to make a fertilized egg, a new animal can develop. *

B4 If an egg cell is to develop into a new animal it must be fertilized. If an egg cell is not fertilized it cannot develop into a new animal. *

B5 During mating the male releases sperm cells either over eggs laid by the female or into the female animal's body. *

B6 Sperm cells are able to swim towards egg cells. *

B7 In each kind of animal the male produces many more sperm cells than the number of egg cells produced by the female. *

B8 In many kinds of animal fertilization takes place inside the female after mating. *

B9 When the male releases sperm cells over eggs outside the female's body, this is called 'external' fertilization.

B10 When the male releases sperm cells which fertilize eggs inside the female's body, this is called 'internal' fertilization.

B11 Internal fertilization is more certain than external fertilization. There is greater chance of sperm and egg meeting.

B12 Many animals put on a display called 'courtship' to attract a partner, prior to mating.

B13 When animals and plants reproduce by sexual reproduction from male and female cells, the young are never exactly like either parent.

B14 Animals having external fertilisation lay many more eggs than animals with internal fertilisation. This compensates for the smaller chances of egg and sperm meeting.

C THE GROWTH OF YOUNG

C1 After fertilization, the fertilized egg cell divides frequently and so begins to grow. *

C2 Food is needed for growth. (Food and Feeding B2) (Growth B1)

C3 Most animals, apart from mammals and microscopic living things, lay eggs and their young begin to grow within the egg.

C4 Eggs which develop outside the mother's body have a foodstore for the growing animal. * (Food and Feeding C10)

C5 A young mammal grows inside its mother in the uterus (womb). *

C6 A new mammal beginning to grow inside its mother gets its food and oxygen from its mother's blood. *

C7 After birth, the young of a mammal feed on their mother's milk.

C8 The ball of growing cells after fertilization is called an 'embryo'.

C9 The time spent by a young mammal inside its mother, before it is born, is called the 'gestation time'.

C10 The time a young mammal spends inside its mother before being born is different for different kinds of mammal.

C11 Different kinds of animal produce different numbers of eggs.

C12 When a new animal, growing in an egg outside its mother, reaches a certain stage of growth it hatches.

C13 Birds' eggs only hatch if the parent keeps them warm.

C14 Eggs which are laid on land have an outer shell which prevents them drying up.

C15 Eggs which are laid in water do not have a shell.

C16 Many animals, like fish and frogs, lay thousands of eggs but only a few develop into adults.

C17 Development of a fertilized egg inside the mother is safer than development outside.

C18 Different kinds of animal vary in the amount of care they devote to their young.

C19 Those animals having external fertilisation and development and little or no parental care lose many of their eggs and young. If they did not produce large numbers of eggs their kind would die out. Those animals with internal fertilisation, growth of the young inside the mother, and good parental care produce less eggs. Fewer eggs are needed when young are not lost.

C20 When animals reproduce sexually the offspring have the chance of being better fitted than the parents for their environment.

D HUMAN REPRODUCTION

(Each school will have its own policy for the contribution which the science teacher makes to sex education. These are important scientific ideas about human reproduction which form the basis of the science component of this part of the curriculum.)

D1 As a boy grows into a young man sperm cells are formed in his testes. *

D2 As a boy grows into a young man his voice breaks, he becomes more muscular, and hair grows on his face, under his arms and around the base of his penis. *

D3 As a girl grows into a young woman egg cells are released from her ovaries. *

D4 As a girl grows into a young woman her breasts develop, her hips widen, and she grows hair under her arms and around her vagina. *

D5 When a girl grows into a young woman she has a period about every four weeks. In between periods, egg cells are released from her ovaries. *

D6 After a period a woman's uterus prepares to receive a fertilized egg. If an egg is not fertilized the uterus lining breaks down to form the next period. *

D7 A man's sperm is introduced into a woman's body during sexual intercourse. *

D8 A baby begins to grow inside a mother's uterus when an egg has been fertilized by a sperm cell after intercourse. *

D9 A baby grows inside its mother for nine months. *

D10 A fertilized egg begins to divide into 2 cells, 4, then 8 and so on. The ball of cells becomes embedded in the uterus of the mother.

D11 A growing baby gets food and oxygen from its mother's blood and it gets rid of its waste into its mother's blood.

D12 If, after the first division of the fertilized egg, the two cells separate and develop separately, identical twins grow.

D13 If two egg cells are fertilized at the same time, non-identical twins grow.

D14 Part of the ball of cells, which grow from a fertilised egg, develops into a placenta through which the growing baby receives food and oxygen and gets rid of waste.

D15 The growing baby is joined by its umbilical cord to the placenta.

E PLANTS PRODUCING SEEDS FROM FLOWERS

(Although pupils will have met the names of flower parts these are unlikely to be part of most pupils' vocabulary).

E1 Many simpler kinds of plant reproduce without producing seeds and without having flowers. Most of the plants we know best, including most trees produce seeds from flowers.

E2 Fruits develop from flowers and the fruits contain seeds.

E3 Most flowers have sepals, petals, stamens, a stigma, a style and an ovary.

E4 Female cells are made in the ovary of a plant. This is the female part of the plant. *

E5 Pollen is made in the stamens of a plant. These are the male parts of a plant. Each pollen grain contains male cells. *

E6 Pollen grains may be blown by wind or carried by insects. Some of them reach the female parts of flowers.

E7 If pollen reaches the female part of the right kind of flower, a seed begins to form. *

E8 A seed begins to form when male and female cells join together. *

E9 The joining of a male cell and a female cell is called fertilization. * (Reproduction B2)

E10 A seed develops with a food store which feeds the new plant when it begins to grow. (Food and Feeding D2)

E11 When pollen lands on the female parts of a flower we call it 'pollination'.

E12 Flowers which are pollinated by insects have brightly-coloured petals, scent or nectar which attract the insects.

E13 Flowers which are wind pollinated have feathery stigmas and dangling stamens.

E14 Pollen grains which are blown by the wind are usually light and powdery.

E15 Pollen grains which are carried by insects are usually spikey or sticky.

E16 Pollen grains from different kinds of flower vary in size and shape.

E17 Sometimes male and female parts are on separate plants. This happens in holly and pussy willow. Sometimes male and female parts are in separate flowers on the same plants, as in the case of hazel.

E18 After pollination and fertilization a fruit begins to develop within the ovary wall.

E19 A few cultivated fruits, bananas and some grapes, do not contain seeds because they have been specially bred without seeds.

E20 A seed is an embryo plant. It has the beginnings of all parts of a new plant.

F SEEDS BEING DISPERSED AND SEEDS GROWING

F1 Young plants have a better chance of getting light, air and water if they are dispersed from the parent plant.

F2 Seeds may be carried away from the parent plant by wind, by animals, or by water.

F3 Fruits help to get seeds dispersed by making them attractive to animals.

F4 Seeds are living things. * ●

F5 A seed needs water, air and warmth to begin to grow. (Growth B3)

F6 When a seed begins to grow we say it 'germinates'.

F7 Wind-dispersed fruits are light. They have wings or parachutes.

F8 Water-dispersed fruits float.

F9 Some animal-dispersed fruits provide food for the animal and the seeds are passed out of the animal unharmed.

F10 Many of the fruits which animals eat are brightly coloured and attractive to animals.

F11 Some animal-dispersed fruits have hooks which stick to fur.

F12 Bursting fruits throw out their seeds.

F13 A seed is a form in which a plant can survive in bad conditions.

F14 By choosing the pollen and ovaries of particular plants to make a new seed, we can produce new kinds of plant. Improved food plants or plants which are resistant to disease can then be cultivated.

F15 Many kinds of seed will not germinate until a period of time has passed since they were formed. This is called the 'dormant period'.

G PLANTS REPRODUCING WITHOUT SEEDS

G1 Some plants can grow from cuttings if they are given the right conditions.

G2 The simplest plants can reproduce by dividing into two, each part becoming a whole new organism.

G3 Reproduction without the joining of male and female cells is called 'asexual reproduction'.

Activities for pupils are listed below, together with references, as suggestions for teachers to consider in preparing an approach to this theme. These activities can be taken together or they can be used individually within other topics as shown in Section 5.2. Most of them will also contribute to core skills and ideas on other maps.

Activity	Reference	Skills Used *	Ideas Developing *	Year	Minimum Time Needed
Looking at fruits and seeds	Science 5/13, Using the Environment 3 Tackling Problems Part 1, pages 50 - 58	1,2,3,4,6, 7,8,9	E2,F1,F2, F3,F4	1	2 hours overlapping with work on variety and adaptation
Looking at flowers	Nuffield Combined Science Teachers' Guide I, pages 228 - 234 and Activities 3, pages 32 - 33, 38 Science 5/13, Using the Environment 3 Tackling Problems Part 1, pages 47 - 48	1,2,3,4,6, 7,8,9	E1,E3,E4, E5,E6,E7, E8,E9	1 or 2	3 hours overlapping with work on variety and adaptation
Growing plants from fruits and seeds	Science 5/13, Using the Environment 2 Investigations Part 2, pages 21 - 32 Teaching Primary Science, Seeds and Seedlings, pages 18 - 23 Nuffield Combined Science Teachers' Guide I, pages 237 - 238 and Activities 3, pages 38 - 39 Nuffield Combined Science Teachers' Guide I, pages 185 - 186, and Activities 2, page 58	1,2,3,4,5, 6,7,8,9,10	A1,E10, F1,F2,F5, F8	2	2 hours spread over several weeks, overlapping with work on growth
Observing animals and their young:					
(a) looking at animals which lay eggs	Science 5/13, Using the Environment 2 Investigations Part 2, pages 26 - 27 Science 5/13, Minibeasts, pages 57 - 64	3,4,6,7,8, 9	Sections A and B C3,C4	2	1½ hours overlapping with work on variety and adaptation
(b) looking at animals whose young develop inside the mother's body	Nuffield Combined Science Teachers' Guide I, pages 205 - 208 and Activities 3, pages 7 - 20		B8,C5,C6, C7	2 or 3	2½ hours overlapping with work on variety and adaptation

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REPRODUCTION 3

Activity	Reference o	Skills Used *	Ideas Developing *	Year	*Minimum* Time Needed
Human reproduction	Nuffield Combined Science Teachers' Guide I, pages 217 - 225 and Activities 3, pages 21 - 31 Biology for the Individual Book 2		D1,D2,D3, D4,D5,D6, D7,D8,D8	2 or 3	3 hours

References and Audio-visual aids

This is a theme where audio-visual aids are of particular importance.

There is a wide range of material available, including the following:

Film-strip series: Starting Life; Babies and Seeds; Mammals and Families; Families from Eggs; Families without Backbones, (Visual Productions)

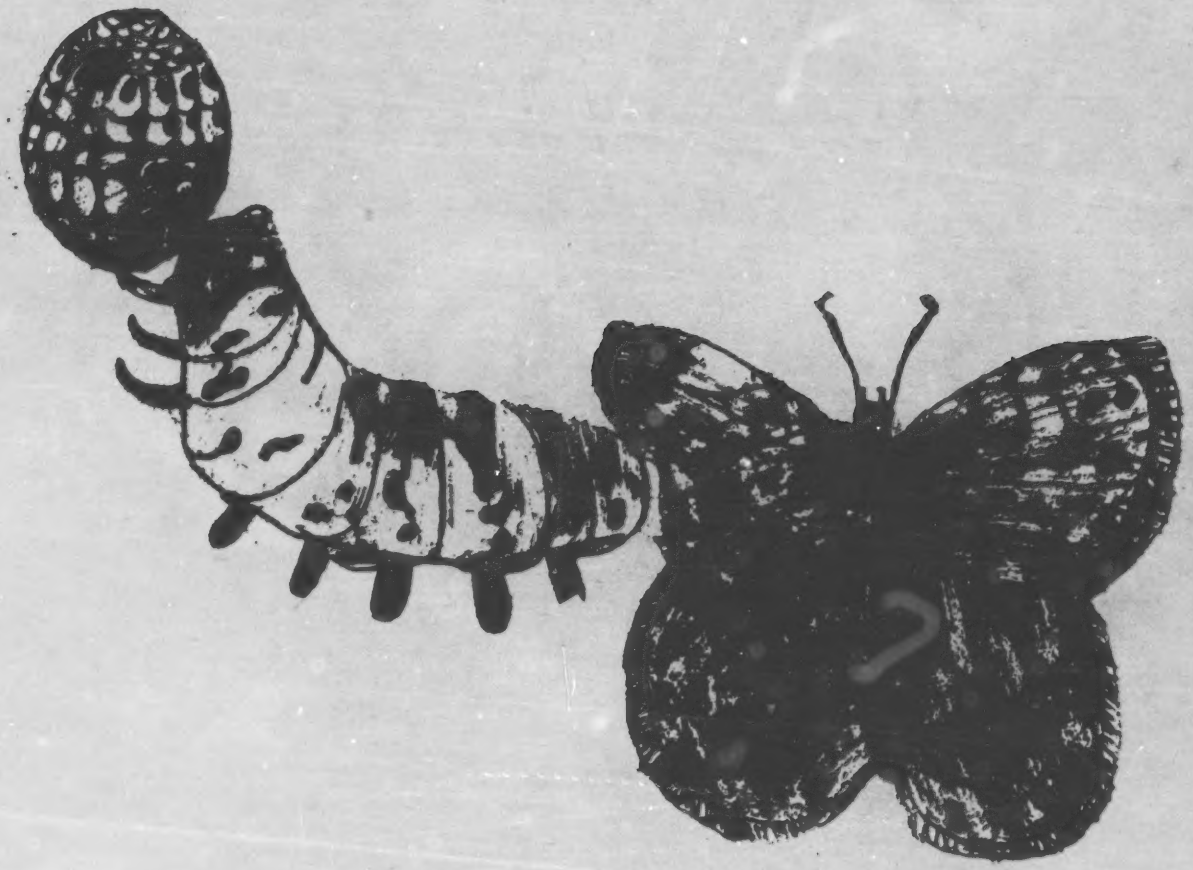
Time-Life Nature Library, 'Growth' Time-Life Books

J. Merigan, Sixth Day, Darton Longman and Todd

o Details of references are given in Appendix 1

* Skills are listed by number with reference to the sequence of investigation techniques at the beginning of this map.

Ideas are listed by section and number with reference to the preceding pages. An activity may simply contribute to the development of an idea or it may be designed specifically to teach a particular idea.



☐ Pupils develop scientific ideas about growth by working like scientists on practical investigations.

☐ A practical science activity for pupils will usually give them the opportunity to work through the sequence of investigation techniques and to begin to develop scientific ideas.

☐ CORE SCIENCE is made up of both the techniques of investigating described below, and the emerging ideas which follow.

CORE SCIENCE STARTS HERE

⇩

PART I - INVESTIGATING

⇩

HAVING IDEAS

1. Making a start

   (a) Asking questions which can be answered by observing or experimenting

   For example, 'How long does a tadpole take to turn into a frog?'

   or (b) Expressing ideas which can be put to the test

   For example, 'Plants grow more quickly in the dark (or in the light)'.

2. Planning observations, fair tests or controlled experiments, in small group discussion, individually or in a whole class

   For example, Planning an experiment to investigate the effect of adding liquid fertilizer to a patch of grass.

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COLLECTING EVIDENCE

3. Making observations, either directly or from experiments, and measuring when it is appropriate

   (a) observing animals and plants over a period of time, noting changes and making measurements of height/length or girth when appropriate. Weight may be recorded on occasion but animals' welfare will be the prime consideration. (See the note following in Section A).

   (b) observing plant and animal life-cycle changes such as those of the butterfly, the locust, the frog, and a flowering plant.

HANDLING EVIDENCE

4. Recording
   - (a) making tables to show sizes, or changes in size:
   - (b) presenting measurements in the form of bar-graphs;
   - (c) drawing from real specimens of animals and plants, to show observations of life-cycle changes.

5. Calculating

   Changes in size (length, girth, height, or weight) from a series of measurements.

6. Talking in small groups or as a whole class, children will explore and develop their own ideas about their experiences.

7. Trying to classify, order and look for patterns

   Pupils will see patterns of change in the measurements and observations they make on growing plants and animals.

   (The patterns which pupils will see follow as scientific ideas). →

8. Trying to explain in terms of cause and effect

   For example, 'The plants did not grow very well because they were cold (or dry).'

   (Explanations of a more sophisticated kind follow as extension ideas). →

9. Describing and presenting evidence and ideas

   Children will prepare tables, drawings and bar-graphs and they will be [illegible]king and writing in their own words.

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MAKING USE OF SCIENTIFIC SKILLS AND IDEAS

10. Solving problems and making useful things

    For example 'Providing the best conditions for a plant to grow.

PART II - DEVELOPING SCIENTIFIC IDEAS

	A OBSERVING GROWTH
CORE ideas are important scientific ideas which the majority of pupils can grasp, by the age of thirteen, in the form in which they are expressed here. They try to show the point reached by the majority of 13-year-olds on their journey towards understanding more formal scientific ideas. Most of the core ideas are patterns which pupils will see in their own practical activities, but there are some which cannot be presented practically and which therefore need verbal or audio-visual teaching; these are indicated by *. ● indicates ideas which pupils have difficulty in grasping but which are so important that they are attempted in the middle years.	(Studying growth will involve children in work with animals. It is important that no sense of experimenting on animals should creep into the work. Pupils will observe, measure and handle animals but only under conditions which ensure the animals' well-being.) A1 Only living things can grow. A2 Growth usually causes an increase in size and weight but when animals get fat we do not call it 'growth'. A3 Growth is faster in early life. A4 Many of the trees we see have taken a very long time to grow. If we cut them down they cannot easily be replaced. A5 The rings we see in a section of tree trunk are formed because the tree grows faster in the spring and summer than it does in autumn and winter. * A6 Growth in plants is affected by the amount of light as well as by supply of nutrients in the soil. ● A7 When we take care of animals and plants we need to give them the right conditions of air, temperature, food, light and water.
SUPPLEMENTARY ideas are no more difficult than core ideas, but they are less important.	A8 No matter which way up we plant a seed the shoot grows upwards and the roots grow downwards. A9 Plants grow towards the strongest source of light. A10 Some seeds take longer to germinate than others. A11 You can tell the approximate age of a tree which has been cut down by counting the rings in the trunk.
EXTENSION ideas are more difficult, abstract ideas which may be understood by pupils who have reached a later stage of conceptual development, characterised by abstract thinking.	*A12 The rate of growth is the amount of growth (the change in size and weight) which occurs in a particular time.* *A13 Plants grow slower in the light than they do in the dark but if they are left in darkness the leaves lose their green colour and the plants eventually die.* *A14 When an animal or plant is growing the number of its cells is increasing.* *A15 Even before seeds grow they are alive and so they can grow when they are given the right conditions.* *A16 The repair of damaged or worn-out parts in both plants and animals is a form of growth called 'regeneration'.* *A17 Growth is affected by temperature, particularly in plants.* *A18 If a tree grows particularly well one year this will show as a wide space between two annual rings.*

B	FOOD FOR GROWTH	C	LIFE CYCLES
B1	Animals and plants need food in order to grow. (Food B2) (Reproduction C2)	C1	All animals and plants have a life-cycle pattern which is repeated in each generation.
B2	Too little food or a poor diet leads to poor growth. * (Food C9)	C2	Flowering plants have a life-cycle made up of beginning to grow, growing, flowering and making seeds.
B3	A seed needs water, air and warmth, to begin to grow. (Reproduction F5)	C3	Most animals have a simple life-cycle passing from egg cell to adulthood without any great change in appearance or way of life.
		C4	Some animals, as they grow, change their appearance very sharply, perhaps more than once before they become adults. We see this when a caterpillar changes into a pupa and then into a butterfly which lays eggs. (Although 'pupa' is the more correct and easier word, many pupils already know and use the word 'chrysalis').
B4	Animals and plants can store some food for future growth.	C5	Plants and animals of different types have life-cycles of different lengths. A life-cycle may be as short as a few days or as long as several years. Some plants (annuals) germinate, grow, flower and fruit then die in a few weeks, some (biennials) may take more than 12 months. A housefly has a life-cycle of a few weeks, an elephant of many years.
		C6	Some trees live for many hundreds of years. The oldest living things on earth are trees.
B5	*Seeds can grow for a time if water, air and warmth are available, but once seeds have used up their own food stores then they need a source of other nutrients and light for healthy growth.*	*C7*	*Even within one species the life-cycle of one living thing does not take exactly the same time as the life-cycle of another.*
		C8	*The temperature of an animal's or plant's surroundings and/or the amount of available food affect the rate at which it completes its life-cycle.*
		C9	*Having a life-cycle with quite different phases enables an animal or plant to 'make the best of several worlds'. This is a way of being adaptable and standing a better chance of surviving.*

Activities for pupils are listed below, together with references, as suggestions for teachers to consider in preparing an approach to this theme. These activities can be taken together or they can be used individually within other topics as shown in Section 5.2. Most of them will also contribute to core skills and ideas on other maps.

Activity	Reference o	Skills Used *	Ideas Developing *	Year	*Minimum* Time Needed
Growing plants from seeds	Science 5/13, Using the Environment 2 Investigations Part 2, pages 21 - 32 Teaching Primary Science, Seeds and Seedlings, pages 16 - 23 Nuffield Combined Science Teachers' Guide I, pages 185 - 188 and Activities 2, page 58	1,2,3,4,5, 6,7,8,9, 10	A1,A2,A4, A6,A7,B3. C2	1 or 2 (summer term)	3 hours spread over several weeks
Looking for changes in plants	Science 5/13, Using the Environment 2 Investigations Part 2, pages 41 - 44 Science 5/13, Trees, pages 13 - 15 and 41	1,2,3,4,6, 7,8,9	A3,C2	1 or 2	short observations at regular intervals especially between April and October and 1 hour for development
Observing the life-cycles of a variety of animals	Science 5/13, Using the Environment 2 Investigations Part 2, pages 32 - 40 and 45 Science 5/13, Minibeasts, pages 57 - 65	1,2,3,4,6, 7,8,9	B1,C1,C3 C4	2	2 hours overlapping with work on animal reproduction
Measuring changes in the mass of gerbils	Nuffield Combined Science Teachers' Guide I, pages 188 - 189	1,2,3,4,5, 6,7,8,9	A1,A2,A3 A7,B1	3 or 4	1 hour and a few minutes at inverals over a period of time
Investigating Growth	Science 5/13, Using the Environment 3 Tackling Problems Part 2, page 18			3 or 4	2 hours

o Details of reference are given in Appendix 1

* Skills are listed by number with reference to the sequence of investigation techniques at the beginning of this map. Ideas are listed by section and number with reference to the preceding pages. An activity may simply contribute to the development of an idea or it may be designed specifically to teach a particular idea.

☐ Pupils develop scientific ideas about food and feeding by working like scientists on practical investigations.

☐ A practical science activity for pupils will usually give them the opportunity to work through the sequence of investigation techniques and to begin to develop scientific ideas.

☐ CORE SCIENCE is made up of both the techniques of investigating described below, and the emerging ideas which follow.

CORE SCIENCE STARTS HERE

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PART I - INVESTIGATING

⇩

HAVING IDEAS

1. Making a start

   (a) Asking questions which can be answered by observing

   For example, 'What do tadpoles eat?'

   or (b) Expressing ideas which can be put to the test

   For example 'The damp bread will go mouldy but the dry piece will not'.

2. Planning observations, fair tests or controlled experiments, in small group discussion, individually or in a whole class

   For example, planning an investigation to find out whether mould grows best in warm or in cold conditions.

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COLLECTING EVIDENCE

3. Making observations, either directly or from experiments, and measuring when it is appropriate

   (a) observing a wide variety of animals and plants in their natural habitats, in some cases through audio-visual aids; looking for evidence of the materials they use as food and for the ways in which they affect one another's feeding habits; using magnifiers and microscopes when they are helpful;

   (b) looking at a variety of different plants to see the ways in which they store food.

HANDLING EVIDENCE

4. Recording

   Making tables and drawings to record observations.

5. Calculating

   There are many calculations which children can make from their measurements but none which is a core skill within this theme.

6. Talking in small groups or as a whole class, children will explore and develop their own ideas about their experiences.

7. Trying to classify, order and look for patterns

   (a) sorting animals and plants into sets according to diet;

   (b) sorting foods according to their origin as plant or animal parts;

   (c) checking for connections in feeding habits so as to trace food chains and food webs.

   (The patterns which pupils will see in their observations follow as scientific ideas). →

8. Trying to explain in terms of cause and effect

   For example, 'This acorn looks to be eaten away. An animal must be using it as food'.

   (Explanations of a more sophisticated kind follow as extension ideas). →

9. Describing and presenting evidence and ideas

   Children will prepare tables, drawings, bar-graphs and they will be talking and writing in their own words.

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MAKING USE OF SCIENTIFIC SKILLS AND IDEAS

10. Discussing problems and practical solutions to problems

    For example,

    (a) the harm done by over-use of fertilizers or insecticides;

    (b) the storage of bread so as to prevent moulds growing;

    (c) the need for more plentiful and more nutritious food;

    (d) a self-help scheme for a village.

PART II - DEVELOPING SCIENTIFIC IDEAS

Science work on this theme is concerned with notions of food and feeding throughout the animal and plant kingdoms as a whole. Focus on human nutrition is assumed to be the particular concern of Home Economics within the curriculum.

	A	WHAT IS FOOD?
CORE ideas are important scientific ideas which the majority of pupils can grasp, by the age of thirteen, in the form in which they are expressed here. They try to show the point reached by the majority of 13-year-olds on their journey towards understanding more formal scientific ideas. Most of the core ideas are patterns which pupils will see in their own practical activities, but there are some which cannot be presented practically and which therefore need verbal or audio-visual teaching; these are indicated by *. ● indicates ideas which pupils have difficulty in grasping but which are so important that they are attempted in the years.	A1	Any material, which is used for growth, by a living thing, can be classed as 'food'. *
	A2	All plants and animals can be used as food by other living things.
	A3	Some living things feed and grow on dead or decaying plants and animals.● (Microscopic Living Things B6)
SUPPLEMENTARY ideas are no more difficult than core ideas, but they are less important.	A4	All food materials contain some water and some foods are made up very largely of water.
	A5	Some living things feed on, or in, the bodies of other living things.
EXTENSION ideas are more difficult, abstract ideas which may be understood by pupils who have reached a later stage of conceptual development, characterised by abstract thinking.		

B MAKING USE OF FOOD

(Pupils will find it easier to grasp ideas about animals' use of food than the equivalent ideas about plants' use of food. The latter are thus considered to be extension ideas for more able pupils).

B1 All living things, both animals and plants, need food and water to stay alive. * (Water B1) (Reproduction F5)

B2 All living things need food to grow, to repair themselves and to keep healthy. * (Growth B1, B3) (Microscopic Living Things C4) (Reproduction C2)

B3 Animals need food to give them energy to move. * (Movement, Forces and Structures E8)

B4 When they use their food animals produce waste materials. *

B5 All living things, plants as well as animals, need food for growth, to repair themselves, to provide energy and to keep healthy.

C ANIMALS FEEDING

C1 Some animals eat a diet made up entirely of plants.

C2 Some animals eat a diet made up entirely of other animals.

C3 Some animals eat a diet which is a mixture of animal and plant foods.

C4 Man has a 'mixed' diet of animal and plant foods.

C5 Animals need to move for feeding in order to collect enough plants or to catch other animals.

C6 Animals break down their food to make it more useful to them. We say they 'digest' it. *

C7 We can trace the chain which links animals eating other animals and plants. This is called a 'food chain'.

C8 At the beginning of every food chain there is a green plant.

C9 Too much food, too little food or the wrong kind of food is harmful to animals. (Growth B2)

C10 Eggs which develop outside the mother's body have a food store for the growing animal. (Reproduction C4)

C11 Animals' mouths are especially suited to the kind of food they eat.

C12 The body of every kind of animal is specially shaped and suited to its diet.

C13 There are some animal or plant materials which man could use as food but which we do not eat because of our cultural habits.

C14 Animals which eat a diet made up entirely of other animals are called 'carnivores'.

C15 Animals which eat a diet made up entirely of plants are called 'herbivores'.

C16 Animals which eat a diet made up of a mixture of animals and plants are called 'omnivores'.

C17 The numbers of animals and plants are kept in check when they are eaten by others.

C18 Animals need to feed on other animals or on plants because they cannot make their own food as plants do.

C19 When man kills a lot of animals or plants because they are 'pests' or 'weeds' he upsets a food web and that will affect the numbers of other plants or animals which were not killed directly.

C20 There are usually many cross-links between food chains, making a 'food web'.

D	PLANTS MAKING FOOD	
D1	Green plants can produce food. ●	
D2	A seed develops with a food store which feeds the new plant when it begins to grow. (Reproduction E10)	
D3	Plants store the food they make in their roots, stems and leaves which animals can eat.	
D4	Some plants store food during one year to use for growth during the next.	
D5	Some plants feed on insects which they trap.	
D6	*When green plants make their food they trap the sun's energy in the food.*	
D7	*Plants need water and dissolved substances, carbon-dioxide and sunlight to make food.*	
D8	*Green plants are at the start of any food chain, because plants can trap the sun's energy to make food and animals cannot.*	

Activities for pupils are listed below, together with references, as suggestions for teachers to consider in preparing an approach to this theme. These activities can be taken together or they can be used individually within other topics as shown in Section 5.2. Most of them will also contribute to core skills and ideas on other maps.

Activity	Reference o	Skills Used *	Ideas Developing *	Year	Minimum Time Needed
Looking for evidence of animals feeding	Science 5/13, Using the Environment 1 Early Explorations, page 30	1,2,3,4,6, 7,8,9	A1,A2,C1, C5	1	1 hour and observations at intervals throughout the year
Investigating the feeding habits of small animals	Science 5/13, Minibeasts, pages 48 - 55 Science 5/13, Using the Environment 2 Investigations Part 1, pages 61 - 66 Science 5/13, Using the Environment 2 Investigations Part 2, page 36	1,2,3,4,6, 7,8,9	A1,B1,B2, B3,B4,C1, C2,C5	2 or 3	2 hours overlapping with work on variety and adaptation
Observing the growth of seeds	Science 5/13, Using the Environment 2 Investigations Part 2, pages 22 - 23	1,2,3,4,6, 7,8,9	D2	2 or 3	½ hour and observations at intervals overlapping with work on reproduction
Observing the feeding habits of birds	Science 5/13, Using the Environment 2 Investigations Part 2, pages 90 - 92	1,2,3,4,6, 7,8,9	A1,B1,B2, B3,B4,C1, C2,C5,C7	1, 2 or 3	1 hour
Discovering food chains	Science 5/13, Using the Environment 3 Tackling Problems Part 1, pages 26 - 27	3,4,6,7,8, 9	C7,C8	2, 3 or 4	1 hour

o Details of references are given in Appendix 1

* Skills are listed by number with reference to the sequence of investigation techniques at the beginning of this map.

Ideas are listed by section and number with reference to the preceding pages. An activity may simply contribute to the development of an idea or it may be designed specifically to teach a particular idea.

SENSITIVITY 6

A MAP FOR INVESTIGATING AND DEVELOPING SCIENTIFIC IDEAS

SENSITIVITY 6

☐ Pupils develop scientific ideas about sensitivity by working like scientists on practical investigations.

☐ A practical science activity for pupils will usually give them the opportunity to work through the sequence of investigation techniques and to begin to develop scientific ideas.

☐ CORE SCIENCE is made up of both the techniques of investigating described below, and the emerging ideas which follow.

CORE SCIENCE STARTS HERE

⇩

PART I - INVESTIGATING

⇩

HAVING IDEAS

1. Making a start

   (a) Asking questions which can be answered by observing or experimenting

   For example, 'Can we recognise a substance by its smell?'.

   or (b) Expressing ideas which can be put to the test

   For example, 'Elbows are more sensitive to heat than hands'.

2. Planning observations, fair tests or controlled experiments, in small group discussion, individually or in a whole class

   For example, planning a fair test of how far away people can hear a particular sound.

⇩

COLLECTING EVIDENCE

3. Making observations, either directly or from experiments, and measuring when it is appropriate

   (a) observing the responses which we and other living things make to sounds, heat, light, smells, tastes and touch in the surroundings;

   (b) observing a wide variety of living things in their natural environments, through audio-visual aids in some cases, looking for ways in which they use their senses, and using magnifiers and thermometers when they are helpful;

   (c) measuring temperatures with a thermometer after recognising that fingers are unreliable.

HANDLING EVIDENCE

4. Recording

   Making tables and bar-graphs to record observations and measurements.

5. Calculating

   There are many calculations which children could make from their measurements but none which is a core skill within this theme.

6. Talking in small groups or as a whole class, children will explore and develop their own ideas about their experiences.

7. Trying to classify, order and look for patterns

   (The patterns which pupils will see in their observations follow as scientific ideas). →

8. Trying to explain in terms of cause and effect

   For example, 'The pupil of my eye has become small because the light is very bright'.

   (Explanations of a more sophisticated kind follow as extension ideas). →

9. Describing and presenting evidence and ideas

   Children will prepare tables and bar-graphs and they will be talking and writing in their own words.

⇩

MAKING USE OF SCIENTIFIC SKILLS AND IDEAS

10. Solving problems and making useful things

    For example,

    (a) making a map for a blind person;

    (b) designing an eye-testing chart;

    (c) choosing the best car colour for being seen by others in fog and rain.

PART II - DEVELOPING SCIENTIFIC IDEAS

A SENSES

CORE ideas are important scientific ideas which the majority of pupils can grasp, by the age of thirteen, in the form in which they are expressed here.

They try to show the point reached by the majority of 13-year-olds on their journey towards understanding more formal scientific ideas.

Most of the core ideas are patterns which pupils will see in their own practical activities, but there are some which cannot be presented practically and which therefore need verbal or audio-visual teaching; these are indicated by *.

● indicates ideas which pupils have difficulty in grasping but which are so important they are attempted in the middle years.

(Many of these ideas about sensitivity are laying foundations for appreciating the inter-relationship between living things and their environment. Pupils will be using and developing their own senses through observing and measuring in their scientific investigations).

A1 All living things have ways of gathering information about their surroundings through their services.

A2 Man and most animals are sensitive to light, sounds or vibrations, smells, tastes, temperature, and touch.

A3 Our bodies have special parts which are sensitive to the environment: ears are sensitive to sound; eyes are sensitive to light; tongues are sensitive to taste; skin is sensitive to touch; noses are sensitive to smells.

A4 With training we can improve our senses.

A5 We use aids, such as magnifiers, to improve upon our senses.

A6 Our senses cannot measure by giving exact numerical values and so we use instruments, such as thermometers, for measuring. (Heat E7)

SUPPLEMENTARY ideas are no more difficult than core ideas, but they are less important.

A7 Most animals rely mainly on one or two senses. We rely particularly upon sight and hearing.

A8 We become used to background smells, sounds and sights so that we no longer notice them even though our senses are still working.

EXTENSION ideas are more difficult, abstract ideas which may be understood by pupils who have reached a later stage of conceptual development, characterised by abstract thinking.

A9 All animals have developed a nervous system which links senses with a means of response.

A10 There are aspects of the environment, such as radio waves or magnetic fields, which we cannot detect.

B TASTE AND SMELL

B1 Man and most other animals can detect some of the materials in the surroundings by their smell.

B2 Taste and smell are closely related senses.

B3 Many animals have a more acute sense of smell than we have.

B4 We can taste materials which are sweet, salty, sour or bitter.

B5 Some kinds of animal depend on their sense of smell for finding their food and for avoiding enemies.

B6 We can detect and recognise very small amounts of some substances in the air and when we smell a material it is because particles of it are present in the air we breathe.

B7 When we smell a material it is because very small particles of that material are dissolving in the mucus lining of our noses.

C SIGHT

C1 The pupil of your eye is like a window which lets light into your eye. * (Light and Colour A2)

C2 The coloured part of your eye alters the size of the pupil and so it controls the amount of light entering your eye.

C3 An eye-ball has a lining which is sensitive to light. *

C4 An eye has a lens which produces a clear picture on the light sensitive lining. *

C5 Too bright a light can permanently damage eyes. It is harmful to look directly at the sun. *

C6 The coloured part of your eye is called the 'iris'.

C7 The light-sensitive lining of your eye is called the 'retina'.

C8 A person may have defects in vision, being unable to see things clearly in focus, and these defects can be corrected by using lenses in spectacles.

C9 Some people are colour-blind and they cannot see any difference between red and green or between green and blue.

C10 Some animals have very simple eyes which can only tell light from dark.

C11 Some kinds of animal, usually those which are themselves brightly coloured, can detect colours.

C12 Many animals detect movement rather than clear shapes.

C13 Animals which have their eyes pointing forward can judge distances.

C14 Insects have many-faceted 'compound' eyes which have a wide range of view and see many small images. They are very sensitive to movement.

C15 Predators and climbers have eyes which face to the front, and this gives them accurate judgment of distance. Animals which are prey of predators have eyes which enable them to see all round.

C16 The retina sends messages from the eye along a nerve to the brain where the messages are interpreted.

C17 Sight is impaired if either the eye, or its related nerve, or the receiving part of the brain, is damaged.

D	TOUCH	E	HEARING SOUNDS
D1	Animals can tell whether things are hotter or colder than their skin.	E1	Sounds which are very loud can permanently damage ears. * (Sound D2)
D2	Because our fingers cannot give a numerical value of temperature we use a thermometer to measure temperature. (Heat E7)	E2	When sounds are unpleasant we call them 'noise' and this can be so disturbing that we talk of 'noise pollution'. (Sound D5)
D3	The body surface of most animals is sensitive to touch.	E3	When we hear sounds we can recognise loudness, pitch (high or low note) and we can usually tell what is making the sound even when we cannot see it. (Sound A2, A3 and A4)
D4	Extreme sensations of touch or temperature are felt as pain. *	E4	Animals make sounds which are important in their communicating with one-another.
		E5	Animals detect and respond to sounds.
		E6	Sound is made when things vibrate. Sometimes it is easy to see the vibration. * (Sound A1)
		E7	Ears play a part in balance as well as in hearing. *
D5	Animals have developed ways of responding to heat and to cold.	E8	Some animals have ears which can be pointed in a particular direction so as to hear sounds better.
D6	Some parts of the body are more sensitive to touch than others.	E9	Some animals send out vibrations of their own which they can detect, as echoes, telling where objects are. Detecting objects by sensing echoes is called 'sonar'.
		E10	Many animals can hear sounds which we cannot hear.
		E11	A person may have defects in hearing. Defects in hearing may be partly overcome by hearing aids.
D7	*We cannot use our hands to tell the temperature of something because our hands only compare with what they have just touched.*	*E12*	*Many animals can respond to vibration outside the range that we can hear; for example, dogs can hear sounds which are too high pitched for us to hear.*
D8	*Animals have sensitive cells in the skin which respond to the pressure of other objects and to temperature.*		

F	THE SENSITIVITY OF PLANTS	
F1	Plants respond to their surroundings more slowly than animals do.	
F2	Plants are sensitive to the direction of light.	
F3	The roots of plants are sensitive to the pull of the earth and they grow towards it.	
F4	The stems of plants are also sensitive to the pull of the earth and they grow away from it.	
F5	All plants are sensitive to the length of day and they respond in particular ways such as growth or leaf-fall.	
F6	Some plants have tendrils or stems which are sensitive to touch, and this enables them to coil around other things for support.	
F7	Some exceptional plants respond quickly to the environment: a mimosa leaf quickly closes if it is touched; a venus fly trap quickly closes if a fly lands upon it.	
F8	*A plant bends towards the light by growing slower on the side which is lighter.*	

Activities for pupils are listed below, together with references, as suggestions for teachers to consider in preparing an approach to this theme. These activities can be taken together or they can be used individually within other topics as shown in Section 5.2. Most of them will also contribute to core skills and ideas on other maps.

Activity	Reference ○	Skills * Used	Ideas * Developing	Years	*Minimum* Time Needed
Listening, smelling, tasting, looking and feeling	Science 5/13, Early Experiences, pages 31 - 38, 58 - 61, 71 - 76 Science 5/13, Using the Environment 1 Early Explorations, pages 25 - 27 Science 5/13, Using the Environment 1 Early Explorations, pages 6 - 27	1,2,3,4,6, 7,8,9,10	A1,A2,A3, B1,B4,F2, F3	1 or 2	6 hours overlapping with work on sound, light and colour
(a) Eyes and looking	Science 5/13, Ourselves, pages 12 - 22	1,2,3,4,5, 6,7,8,9,10	A1,A3,C1, C2		
(b) Ears and hearing	Science 5/13, Ourselves, pages 22 - 25	1,2,3,4,5, 6,7,8,9,10	A1,A3,A4, F2,F3,F6		
(c) Noses and smelling	Science 5/13, Ourselves, page 26	1,2,3,4,5, 6,7,8,9,10	A1,A3,A4, B1		
(d) Mouths, teeth and tasting	Science 5/13, Ourselves, pages 27 - 28	1,2,3,4,5, 6,7,8,9,10	B4		
(e) Feeling with fingers and toes	Science 5/13, Ourselves, pages 31, 41 - 42	1,2,3,4,5, 6,7,8,9,10	A4,D1,D2		
Looking for sensitivity in animals and plants	Science 5/13, Using the Environment 2 Investigations Part 1, pages 24 - 26 Science 5/13, Using the Environment 3 Tackling Problems Part 2, page 37	1,2,3,4,6, 7,8,9	B1,B2,B3, B4,D3,E1, E2,F2,F4, F5	2 or 3	2 hours within a longer study overlapping with work on variety and adaptation
Investigating light	Science 5/13, Holes, Gaps and Cavities, pages 28 - 29, 42 - 44	1,2,3,4,5, 6,7,8,9,10	A5,C1,C2, C3,C4,C5	2	2 hours within a longer study overlapping with work on light and colour
Investigating sounds	Science 5/13, Holes, Gaps and Cavities, page 19	1,2,3,4,5, 6,7,8,9,10	F3,F6	2	2 hours within a longer study overlapping with work on sound

/cont...

SENSITIVITY [6]

Activity	Reference o	Skills Used *	Ideas Developing *	Year	*Minimum* Time Needed
Measuring temperature	Nuffield Combined Science Teachers' Guide I, pages 18 - 23 and Activities 1, pages 10 - 11	1,2,3,4,5, 5,6,8,9,10	A6,D1,D2	3	1 hour within a longer study overlapping with work on heat

o Details of references are given in Appendix 1

* Skills are listed by number with reference to the sequence of investigation techniques at the beginning of this map.

Ideas are listed by section and number with reference to the preceding pages. An activity may simply contribute to the development of an idea or it may be designed specifically to teach a particular idea.

☐ Pupils develop scientific ideas about microscopic living things by working like scientists on practical investigations.

☐ A practical science activity for pupils will usually give them the opportunity to work through the sequence of investigation techniques and to begin to develop scientific ideas.

☐ CORE SCIENCE is made up of both the techniques of investigating described below, and the emerging ideas which follow.

CORE SCIENCE STARTS HERE

⇩

PART I - INVESTIGATING

⇩

SPECIAL NOTE ON SAFETY

It is essential that attempts to grow bacteria should only be made under the direction of the Head of Science, who has attended an appropriate course, and in accordance with the Authority's regulations on Safe Handling of Micro-organisms. (See the Handbook for Schools, White Section, sub-section N).

HAVING IDEAS

1. Making a start
   - (a) Asking questions which can be answered by observing or experimenting
     For example, 'Are there small organisms in water (or air)?'.
   - or (b) Expressing ideas which can be put to the test
     For example, predicting which bread, of samples in different conditions, will go mouldy.
2. Planning observations, fair tests or controlled experiments, in small group discussion, individually or in a whole class
   For example, observing growth of yeast at different temperatures.

⇩

COLLECTING EVIDENCE

3. Making observations, either directly or from experiments, and measuring when it is appropriate
   - (a) observing with the aid of a microscope, a wide variety of microscopic living things, looking for similarities and differences in their appearance and their behaviour;
   - (b) observing colonies of bacteria and moulds on sealed agar plates using magnifiers when they are helpful;
   - (c) exposing agar plates and handling sealed agar plates safely, sterilizing equipment using a pressure cooker.

HANDLING EVIDENCE

4. Recording
   (a) careful labelling of samples or agar plates;
   (b) keeping records, in writing and in table form, of observations from experiments which continue over a period of time.

5. Calculating
   Trying to make an estimate of the size of micro-organisms seen through a lens or a microscope.

6. Talking in small groups or as a whole class, children will explore and develop their own ideas about their experiences.

7. Trying to classify, order and look for patterns
   Pupils will see examples of groups of micro-organisms but they would be unlikely to be able to sort micro-organisms for themselves.
   (The patterns which pupils will see in their observations follow as scientific ideas). →

8. Trying to explain in terms of cause and effect
   For example, 'The milk went sour because micro-organisms grew in it'.
   (Explanations of a more sophisticated kind follow as extension ideas). →

9. Describing and presenting evidence and ideas
   Children will make drawings and tables and they will be talking and writing in their own words.

⇩

MAKING USE OF SCIENTIFIC SKILLS AND IDEAS

10. Discussing problems and practical solutions to problems
    For example,
    (a) the safe storage of food;
    (b) the safe use of left-over food.

PART II - DEVELOPING SCIENTIFIC IDEAS

	A	WHAT ARE MICROSCOPIC LIVING THINGS LIKE?
CORE ideas are important scientific ideas which the majority of pupils can grasp, by the age of thirteen, in the form in which they are expressed here. They try to show the point reached by the majority of 13-year-olds on their journey towards understanding more formal scientific ideas. Most of the core ideas are patterns which pupils will see in their own practical activities, but there are some which cannot be presented practically and which therefore need verbal or audio-visual teaching; these are indicated by *. ● indicates ideas which pupils have difficulty in grasping but which are so important that they are attempted in the middle years.	A1	All those living things which are so small that you need a magnifier or a microscope to see them, are called 'micro-organisms' or 'microscopic living' things. *
	A2	Some of the kinds of micro-organism which we find are: fungi; single-celled animals which live in water and moist places; small worms; algae; bacteria and viruses.
	A3	Examples of the group of micro-organisms called 'fungi' are moulds, and those fungi which produce mushrooms and toadstools.
SUPPLEMENTARY ideas are no more difficult than core ideas, but they are less important.	A4	Viruses are the smallest living things.
	A5	Most fungi are made up of hair-like threads which can sometimes be seen with a magnifier.
	A6	Single-celled animals which live in water are called 'protozoa'.
	A7	Protozoa can move about freely in moist or wet places.
EXTENSION ideas are more difficult, abstract ideas which may be understood by pupils who have reached a later stage of conceptual development, characterised by abstract thinking.	*A8*	*There are at least as many different kinds of micro-organism as there are kinds of animal and plant which you can see.*
	A9	*A large group of micro-organisms growing together can often be seen with the naked eye even though any one of them is microscopic.*
	A10	*Individual micro-organisms may be made up of very few cells or even of a single cell.*
	A11	*Bacteria are single cells.*
	A12	*The bloom on grapes and plums is caused by a layer of yeast cells.*
	A13	*Fungi cannot make their own food as green plants do.*

B WHERE DO MICRO-ORGANISMS LIVE?

B1 Micro-organisms are found almost everywhere; on hands, hair and even on the droplets of water and dust in the air. ●

B2 Micro-organisms grow on whatever they can use as food.

B3 Water, especially stagnant water, contains many kinds of micro-organism.

B4 We expect to find fungi feeding and growing on moist materials.

B5 Some micro-organisms grow on our food.

B6 Some bacteria feed and grow on dead plants and animals, causing the dead things to rot. ●
(Food and Feeding A3)

B7 Some micro-organisms are able to grow on such things as concrete or plastic.

B8 Some micro-organisms can survive in extreme conditions of heat or cold.

B9 The entire soil is penetrated by fine threads of fungi.

B10 Each kind of micro-organism has its own ideal temperature and environment.

C HOW DO MICRO-ORGANISMS GROW AND MULTIPLY?

C1 Many single-cell micro-organisms multiply simply by splitting into two. *

C2 Micro-organisms can split as often as once every 20 minutes and so one organism can soon become many thousands, even millions within 24 hours. *

C3 Micro-organisms can soon build up into very large numbers when it is warm and they have food to grow on. *

C4 Micro-organisms need food in order to grow: they take food from the things they grow on, or in. * (Food.... B2)

C5 Micro-organisms change the materials on which they grow. (Examples of changes are referred to in D4, D5 and E11).

C6 Micro-organisms grow faster and multiply faster when it is warmer. Their growth is slowed down by cooling, and particularly by freezing.

C7 Most micro-organisms are killed at high temperatures.

C8 Fungi multiply by making spores which are carried in the air.

C9 Toadstools and mushrooms are the fruiting bodies from fungi in the soil, and they produce spores.

C10 Some bacteria need air in order to live but others can live without air.

C11 Viruses infect not only man but also other living things, including plants and even bacteria.

C12 Some bacteria form 'spores' when their environment becomes hostile. These spores are very resistant and they are not killed by boiling or freezing.

D	USEFUL MICRO-ORGANISMS	E	HARMFUL MICRO-ORGANISMS
D1	Many micro-organisms are useful, necessary and helpful to man. (This idea will arise from pupils grasping some of the supplementary ideas of Section D.) *	E1	Some micro-organisms are harmful to man, but most of them are not harmful.
D2	Useful micro-organisms can only be effective if they have the right conditions and enough time for growing.		
D3	If micro-organisms did not exist, then dead plants and animals would not decay. *		
D4	Micro-organisms grow on old wood and dead plants and these gradually break up into the fine meteriel called 'humus' which forms part of the soil.	E2	Some moulds are harmful, attacking timber in buildings or even living trees.
D5	Some bacteria, growing in milk, turn it into cheese.	E3	When bacteria grow on the food left on teeth they result in tooth decay.
D6	Some bacteria, growing in milk, turn it into yoghourt.	E4	The common cold is caused by a virus.
D7	Bacteria are needed for the production of vinegar.	E5	Rabies is caused by a virus.
D8	Micro-organisms play an important part in the treatment of sewage.	E6	Mumps is caused by a virus.
D9	Micro-organisms play a part in the purification of water in rivers.	E7	Chickenpox is caused by a virus.
D10	Yeast growing in dough makes it rise.	E8	Harmful protozoa are carried by flies and mosquitos.
D11	Yeast growing in fruit juice turns it into wine; and yeast is used in beer-making.	E9	Malaria is caused by a protozoan injected into a man's blood by a mosquito.
		E10	Sleeping sickness is caused by a protozoan injected into a man's blood by an insect.
		E11	Dry rot is caused by a fungus.
		E12	Athlete's foot is caused by a fungus.
		E13	Dutch elm disease, which has killed thousands of elm trees, is caused by a fungus carried by an insect.
		E14	Some fungi attack crops.
		E15	Scarlet fever is caused by bacteria.
		E16	Tonsilitis is caused by bacteria.
D12	*When bacteria cause dead animals and plants to rot and form humus then the materials from the dead things can be used again by other plants.*	*E17*	*When food goes mouldy it is because spores from the air have landed and begun to grow on it.*
		E18	*When bacteria grow on dirty teeth they make acids and it is the acids which cause tooth decay.*

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F COMBATING HARMFUL BACTERIA

F1 Harmful bacteria are often called 'germs'. *

F2 We say something is 'sterile' if all micro-organisms in or on it have been destroyed. *

F3 It is very hard to keep a thing sterile because bacteria are always carried by fingers, clothes, air and water.

F4 We can combat harmful bacteria by taking care to keep hands, surfaces and eating utensils clean so that bacteria do not grow on them.

F5 Cooking food kills any bacteria which are there, but warming up only encourages them to grow. *

F6 When we keep food in a refrigerator or a freezer we slow down the growth of any bacteria which are in or on the food. *

F7 Scientists have developed ways of protecting people against some of the harmful micro-organisms by vaccination. *

F8 Some chemicals, like soap, kill harmful organisms.

F9 Disinfectants kill bacteria but they are poisonous, so they can only be used for cleaning and not as medicine or ointment.

F10 Antiseptics kill bacteria, and they are safe to use on skin but they are poisonous and cannot be taken as medicine.

F11 Antibiotics kill bacteria, and they are used as a medicine.

F12 Sterilized and UHT milk have had all bacteria killed by heat.

F13 Pasteurised milk has had most bacteria, the harmful ones, killed by heat.

F14 Antibiotics do not work on viruses.

F15 Food can be preserved by canning, by drying, by smoking, salting and freeze-drying.

F16 In order to keep an object sterile we have to prevent even one organism coming in contact with the object.

F17 Some organisms are becoming resistant to antibiotics or other chemicals.

F18 Some moulds produce chemicals, like penicillin, which kill bacteria. Such chemicals are called 'antibiotics'.

F19 Ways of preserving food depend either upon removing the warmth and water needed for micro-organisms to grow, or upon adding chemicals in which they can't survive.

Activities for pupils are listed below, together with references, as suggestions for teachers to consider in preparing an approach to this theme. These activities can be taken together or they can be used individually within other topics as shown in Section 5.2. Most of them will also contribute to core skills and ideas on other maps.

Activity	Reference	Skills Used *	Ideas Developing *	Year	Minimum Time Needed
Looking at fungi in the environment	Science 5/13, Trees, pages 55 - 56	1,3,4,6,7, 9	A3	1 or 2	1 hour within a wider study of the environment
Looking more closely at very small living things:					
(a) moulds and fungi	Biology for the Individual Book 6, pages 2 - 3	3,4,6,7,9	A1,A2,A3, B2,B4,B5	4	1 hour
(b) prctozoa	Biology for the Individual Book 6, pages 4 - 5 Nuffield Combined Science Teachers' Guide II, pages 5 - 7 and Activities, page 7	3,4,6,7,9	A1,A2,B3, C1	4	1 hour
(c) types of microbes and how they affect our lives	Biology for the Individual Book 6, pages 9 - 11 Nuffield Combined Science Teachers' Guide II, pages 90 - 92	3,4,6,7,8	A1,A2,B4, B6,D1,D3, E1	4	1 hour
(d) yeast	Biology for the Individual Book 6, pages 16 - 25 Nuffield Combined Science Teachers' Guide II, pages 92 - 96 Science 5/13, Early Experiences, page 54	3,4,5,6,8, 9	C1,C2,C3, C4,C5,C6, C7,D2	4	2 hours
Preventing soup or gravy from going bad	Biology for the Individual Book 6, pages 26 - 27 Nuffield Combined Science Teachers' Guide II, pages 103 - 106	3,4,6,7,8, 9,10	C2,C3,C4, C5,C6,C7, F2,F4,F5	4	1 hour to set up plus 1 hour recording over several weeks
Finding out where bacteria are to be found	Biology for the Individual Book 6, pages 28 - 38 Nuffield Combined Science Teachers' Guide II, pages 110 - 113 and Activities 7, pages 18 - 22	1,2,3,4,6, 7,8,9,10	B1,B2,F2, F3,F4,F5, F8	4	1 hour to set up plus 1 hour for recording and developing

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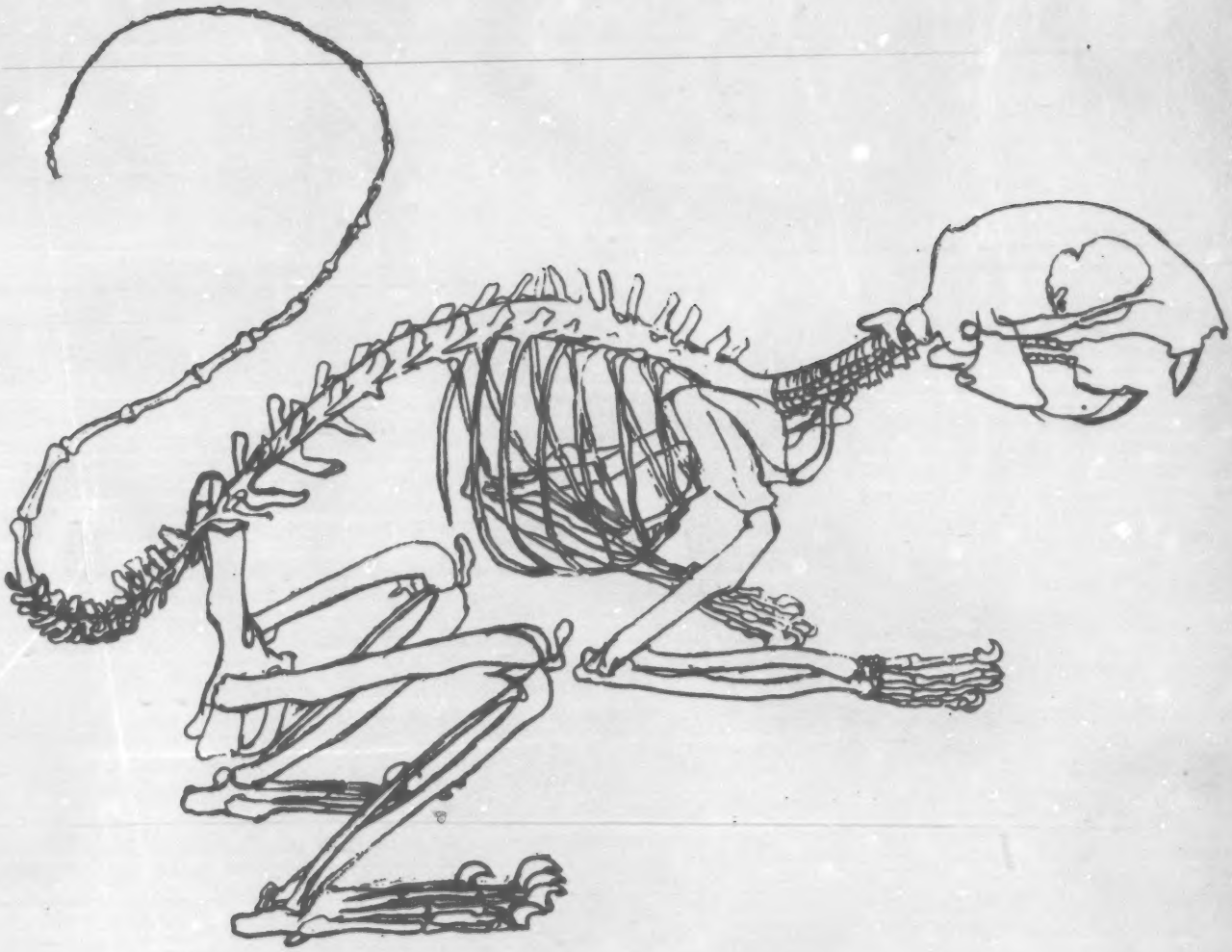
Activity	Reference o	Skills Used *	Ideas Developing *	Year	*Minimum* Time Needed
Looking for micro-organisms in food	Biology for the Individual Book 6, pages 40 - 47 Nuffield Combined Science Teachers' Guide II, pages 118 - 120 and Activities 7, pages 26 - 27	1,2,3,4,6, 7,8,9,10	C5,C6,C7, F4,F5,F6	4	2½ hours
Finding out how fast bacteria can grow	Biology for the Individual Book 6, pages 48 - 50 Nuffield Combined Science Activities 7, page 28	1,5,6,7,9	C1,C2,C3	4	1 hour
Killing harmful micro-organisms	Biology for the Individual Book 6, pages 52 - 57 Nuffield Combined Science Teachers' Guide II, pages 120 - 123 and Activities 7, pages 28 - 30	2,3,4,6,7, 8,9,10	F8	4	1 hour to set up and 1 hour to record and develop

o Details of references are given in Appendix 1

* Skills are listed by number with reference to the sequence of investigation techniques at the beginning of this map.

Ideas are listed by section and number with reference to the preceding pages. An activity may simply contribute to the development of an idea or it may be designed specifically to to teach a particular idea.



☐ Pupils develop scientific ideas about movement, forces and structures by working like scientists on practical investigations.

☐ A practical science activity for pupils will usually give them the opportunity to work through the sequence of investigation techniques and to begin to develop scientific ideas.

☐ CORE SCIENCE is made up of both the techniques of investigating described below, and the emerging ideas which follow.

CORE SCIENCE STARTS HERE

⇩

PART I - INVESTIGATING

⇩

HAVING IDEAS

1. Making a start

   (a) Asking questions which can be answered by observing or Experimenting

   For example, 'Are some shapes better than others for moving through water?'

   or (b) Expressing ideas which can be put to the test

   For example, 'It will take a bigger force to move the book on a rougher surface'.

2. Planning observations, fair tests or controlled experiments in small group discussion, individually or in a whole class

   For example, planning the testing of different bridge designs.

⇩

COLLECTING EVIDENCE

3. Making observations, either directly or from experiments, and measuring when it is appropriate

   (a) feeling the strength of a wide range of forces including: weight (the pull of gravity), the force of magnetism; forces needed to make things move or to stop them moving;

   (b) observing the movement of a wide variety of animals with the help of audio-visual aids;

   (c) observing and measuring the change in shape of elastic materials and springs when forces are applied;

   (d) observing the change in shape of structures when forces are applied, and measuring their breaking strengths;

   (e) looking at structures in the environment in search of strong shapes;

   (f) feeling changes in our own muscles when we are lifting weights;

   (g) using levers and pulleys to move things more easily;

   (h) using forcemeters to measure a wide variety of push and pull forces, including weight;

   (j) measuring the time taken for distances to be covered by moving things.

HANDLING EVIDENCE

4. Recording
   - (a) using tickertape to make a 'bar-graph' of the extension of a spring or an elastic material;
   - (b) making tables and bar-graphs to record measurements and observations;
   - (c) making drawings and diagrams of equipment.

5. Calculating
   - (a) the pull of the earth on an object when its mass is known;
   - (b) the extension, in cms, of a spring or an elastic material as it is loaded.

6. Talking in small groups or as a whole class, children will explore and develop their own ideas about their experiences.

7. Trying to classify, order and look for patterns
   - (a) classifying forces as push or pull;
   - (b) classifying structures as strong or weak.

   (The patterns which pupils will see in their observations follow as scientific ideas). →

8. Trying to explain in terms of cause and effect

   For example, accounting for changes in movement in terms of forces.

   (Explanations of a more sophisticated kind follow as extension ideas). →

9. Describing and presenting evidence and ideas

   Children will prepare tables, bar-graphs and drawings and they will be talking and writing in their own words.

⇩

MAKING USE OF SCIENTIFIC SKILLS AND IDEAS

10. Solving problems and making useful things

    For example,
    - (a) making it easier to move a heavy object;
    - (b) finding the best stream-lined shape for moving through water;
    - (c) designing towers, bridges and strong structures from weak materials.

PART II - DEVELOPING SCIENTIFIC IDEAS

	A	RECOGNISING FORCES: WHAT DO FORCES DO?
CORE ideas are important scientific which the majority of pupils can grasp, by the age of thirteen, in the form in which they are expressed here. They try to show the point reached by the majority of 13-year-olds on their journey towards understanding more formal scientific ideas. Most of the core ideas are patterns which pupils will see in their own practical activities, but there are some which cannot be presented practically and which therefore need verbal or audio-visual teaching; these are indicated by *. ● indicates ideas which pupils have difficulty in grasping but which are so important that they are attempted in the middle years.	A1	A force can be a push, a pull or a twist.
	A2	Forces can change movement: they can either start it, stop it, speed it up or slow it down; nothing can be made to move or be made to stop without a force being applied.
	A3	Forces can change the shape of things, and forces can even break things.
	A4	Large masses require greater forces to start them moving, than do smaller masses.
	A5	Fast moving objects are more difficult to stop than slower moving objects of the same mass.
	A6	Larger masses are more difficult to stop than smaller masses moving at the same speed.
	A7	Some forces, gravity, electric charges and magnetism, can make objects move without touching them. (Magnets and Magnetism D10)
	A8	A force may be acting when we can't see any movement or change of shape.●
SUPPLEMENTARY ideas are no more difficult than core ideas, but they are less important.	A9	Some materials resist forces better than others. They do not change their shape so much when a force acts on them.
	A10	Forces can change the direction of something which is moving.
EXTENSION ideas are more difficult, abstract ideas which may be understood by pupils who have reached a later stage of conceptual development, characterised by abstract thinking.	*A11*	*An object which does not move when a force is acting on it, is providing an equal opposing force.*

B HOW DO FORCES ARISE?

B1 Anything which is moving can exert a force.

B2 The earth, and the moon have a pulling force. We call this pull 'gravity'.*(The Earth in the Universe D4 and E6)

B3 The pull of the earth is what gives an object its weight. * (The Earth in the Universe E7)

B4 We use the word 'mass' when we refer to the amount of material in an object. The word 'weight' refers to the force with which the earth pulls an object downwards. ●

B5 Magnets produce a force which we call 'magnetism'. (Magnets and Magnetism D2)

B6 There are many examples of forces at work in nature.

B7 Thunderstorms, wind, volcanoes, earthquakes, waterfalls, and sea waves are all examples of forces in nature.

B8 When animals move they produce forces.

B9 All objects have a force of gravity but we can only detect it for enormous objects like planets.

B10 The pull of the moon is less than the pull of the earth, and so its gravity is less and things weigh less on the moon.

B11 When plants grow they produce forces.

C MEASURING FORCES

C1 We can use the stretching or compressing of springs, or of elastic materials, to measure forces.

C2 An elastic material or a spring stretches when it is loaded.

C3 When you unload a stretched spring it usually goes back to normal, but above a certain load the spring is over-loaded and it will not return normal when the load is removed.

C4 Forces are measured with a newton-meter which contains a spring.

C5 We measure forces in units called 'newtons'. *

C6 The pull of the earth on 1kg. is about 10 newtons.

C7 If we spread a force over a larger surface then it has a smaller effect than it has if we concentrate it on a point.

C8 Springs stretch evenly as you add bigger loads provided that you do not overstrain them.

C9 As a loaded spring gets near to being overstrained it stretches by larger amounts as you add extra loads.

C10 The thickness of wire used in a spring affects how big a load it can take before breaking.

C11 The units, newtons, which we use in measuring forces, are named after the scientist, Sir Isaac Newton.

C12 Sometimes forces work together, sometimes they oppose one another.

C13 If two forces act together in the same direction, then the resulting force will be the sum of the two separate forces.

C14 If two forces act in opposition to one another, in opposite directions, then the resulting force can be calculated by taking the difference of the two separate forces.

C15 We can measure the resulting force which is produced when several forces act together or against one another.

C16 If two forces act against one another but not in line then they make an object rotate.

C17 A force can be spread over a large or a small area. We talk about 'pressure' to take account of the area a force acts upon. If you spread the same force over a bigger area you reduce the pressure.

D	USING FORCES: MAKING THINGS MOVE	E	MOVEMENT
D1	When an object slides on a surface, the surface makes it difficult for the object to move.	E1	Something moving faster covers a certain distance in a shorter time.
D2	We say that there is 'friction' between the surface and the sliding object. Friction is a force between the surfaces. *	E2	When we move it is our muscles which produce the force needed to pull our bones. A skeleton cannot move.
D3	A smooth surface causes less friction than a rough one.	E3	We can feel muscles tightening when we move or lift weights.
D4	When two surfaces are rubbed together the friction produces heat.	E4	A muscle can only pull a bone; it cannot push.
D5	Friction is decreased by lubricants like oil, ball-bearings or air-cushions. All these things make moving easier.	E5	Muscles often work in pairs to move bones.
D6	Even a strong man cannot exert very big forces and so we use simple tools to make our arms and legs more effective.	E6	Both air and water create friction when an object moves through them.
		E7	A streamlined shape for objects and animals makes it easier for them to move.
		E8	Animals need food to give them the energy to move. * (Food and Feeding B3)
D7	Vehicles and animals could not move if it were not for friction between tyres or feet and the ground.	E9	Because they can move animals can find food and shelter.
D8	A small force, exerted by a man pushing on the longer arm of a lever, will move a large weight placed near the pivot.	E10	Because they can move animals are able to escape from their enemies.
D9	Levers, pulleys, wheels, slopes and screws are examples of simple tools which can be used to make small forces more effective.	E11	All but the tiniest animals use muscles to move whether they walk, swim or fly.
D10	The force of moving air can be used to drive ships, mills and electricity generators.	E12	We have to make some of our muscles move but others go on working without our thinking about it.
D11	The force of moving water can be used to drive mills and electricity generators.	E13	The shape of an animal is related to its way of moving.
		E14	Muscles can be strengthened by exercise.
D12	*A machine can make a force bigger or alter the way it acts.*	*E15*	*The speed of movement can be calculated by dividing the distance moved by the time taken to cover that distance.*
D13	*When forces are balanced about a pivot the force x distance on one side is equal to the force x distance on the other.*	*E16*	*Bones act as levers when they are moved by muscles.*
D14	*When a force acts upon an object the object will slide, if it is free to slide, provided that the force overcomes the frictional force between the object and what it rests upon.*		
D15	*Because of friction there is no such thing as perpetual motion.*		

F	STRUCTURE AND SHAPE	
F1	The strength of an object depends upon two things: the material of which it is made and the way it is built - its structure.	
F2	A triangle is a strong structure.	
F3	A tube is a strong structure.	
F4	An arch is a strong structure.	
F5	An object with a wide or a heavy base cannot easily be knocked over.	
F6	The shape and size of an animal is related to the environment in which it moves. (Variety and Adaptation D1).	
F7	Corrugated materials are stronger than flat sheets of the same material.	
F8	Animals can spread their legs out to make themselves more stable.	
F9	*The shape and size of a plant is related to the forces it has to withstand.*	

Activities for pupils are listed below, together with references, as suggestions for teachers to consider in preparing an approach to this theme. These activities can be taken together or they can be used individually within other topics as shown in Section 5.2. Most of them will also contribute to core skills and ideas on other maps.

Activity	Reference	Skills Used *	Ideas Developing *	Year	Minimum Time Needed
Making and testing bridges	Science in a Topic, Houses and Homes, pages 38 - 39 Science 5/13, Structures and Forces, Stages 1 and 2, pages 39 - 47, 57, 61 - 62, 88 - 89 Science in a Topic, Roads, Bridges and Tunnels, pages 17 - 48	1,2,3,4,6, 7,8,9,10	F1,F2,F3, F4	1 or 2	2 hours overlapping with work on materials
Observing animal movement	Nuffield Combined Science Teachers' Guide I, pages 122 - 124 and Activities 2, pages 2 - 8 Biology for the Individual Book 3, pages 2 - 5, 10 - 11, 26 - 27, 32 - 33	3,4,6,7,8, 9	E2,E3,E4, E5,E6,F5, F6	2	1 hour and observations throughout the year overlapping work on variety and adaptation
Investigating Forces	Nuffield Combined Science Teachers' Guide I, pages 126 - 131 and Activities 2, pages 10 - 20 Science 5/13, Structures and Forces, Stage 3, pages 15 - 17	1,2,3,4,5, 7,8,9,10	A1,A2,A3, A4,A5,A6, A7,A8,B1, B5,B6,C1, C2,C4,C5, C7	3	4 hours
Stretching Springs	Science 5/13, Metals, pages 39 - 40 Nuffield Combined Science Teachers' Guide I, pages 139 - 146 and Activities 2, pages 28 - 34	1,2,3,4,5, 6,7,8,9,10	C2,C3	3	1 hour
Feeling the pull of the earth	Nuffield Combined Science Teachers' Guide I, pages 148 - 149	3,4,6,7,8, 9	A7,A8,B2, B3,B4,C6	3	1 hour overlapping with work on the earth in the universe
Measuring speed	Science 5/13, Science from Toys, pages 41 - 42, 61 - 62 Science 5/13, Using the Environment 1 Early Explorations, page 57	3,4,5,6,7, 8,9	E1	3	1½ hours

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Activity	Reference ○	Skills Used *	Ideas Developing *	Year	Minimum Time Needed
Investigating streamlined shapes	Biology for the Individual Book 3, pages 6 - 8	1,2,3,4,5, 6,7,8,9,10	E1,E6,E7	4	1 hour
Making things move more easily	Nuffield Combined Science Teachers' Guide I, pages 131 - 134	1,2,3,4,6, 7,8,9,10	A4,D1,D2, D3,D4,D5	4	3 hours
Looking at simple machines	Science in a topic, Houses and Homes, pages 44 - 46	3,4,6,7,8, 9,10	D6	4	2 hours

○ Details of references are given in Appendix 1

* Skills are listed by number with reference to the sequence of investigation techniques at the beginning of this map.

Ideas are listed by section and number with reference to the preceding pages. An activity may simply contribute to the development of an idea or it may be designed specifically to teach a particular idea.

☐ Pupils develop scientific ideas about heat by working like scientists on practical investigations.

☐ A practical science activity for pupils will usually give them the opportunity to work through the sequence of investigation techniques and to begin to develop scientific ideas.

☐ CORE SCIENCE is made up of both the techniques of investigating described below, and the emerging ideas which follow.

CORE SCIENCE STARTS HERE

⇩

PART I - INVESTIGATING

⇩

HAVING IDEAS

1. Making a start

   (a) Asking questions which can be answered by observing or experimenting;

   For example, 'Which materials are best for keeping things warm?'

   or (b) Expressing ideas which can be put to the test

   For example, 'Soup stays hot longer in a plastic container than in a metal container'.

2. Planning observations, fair tests or controlled experiments, in small group discussion, individually or in a whole class

   For example, designing a fair test of materials as insulators.

⇩

COLLECTING EVIDENCE

3. Making observations, either directly or from experiments, and measuring when it is appropriate

   (a) looking for changes in materials when they are heated or cooled, noticing noises and smells as well as visible changes; (Goggles, safety screens, blue glass, mercury thermometers, bunsen-burners, tripods, gauges, protective mats, laboratory glassware, tongs, test-tube-holders and test-tube racks will be used.)

   (b) comparing the feel of those materials which keep things warm with the feel of those which do not;

   (c) measuring a variety of temperatures between $-10^{\circ}C$ and $200^{\circ}C$;

   (d) trying to take readings of a thermometer at particular time intervals.

HANDLING EVIDENCE

4. Recording
   - (a) making tables of temperature readings;
   - (b) making tables to record changes observed;
   - (c) plotting graphs to show temperature changes with time, given a teacher's help with scales and axes.

5. Calculating
   - (a) temperature changes from two temperature readings;
   - (b) the time taken for water to cool when it is surrounded by different insulators.

6. Talking in small groups or as a whole class, children will explore and develop their own ideas about their experiences.

7. Trying to classify, order and look for patterns
   - (a) sorting materials into those which keep things warm and those which do not;
   - (b) sorting materials into solids, liquids and gases;
   - (c) sorting materials into those which are changed by heat and those which are not;
   - (d) sorting materials into those which feel warm and those which feel cold.

   (The patterns which pupils will see in their observations follow → as scientific ideas).

8. Trying to explain in terms of cause and effect

   For example 'The end of the metal rod got hot because we heated the other end'.

   (Explanations of a more sophisticated kind follow → as extension ideas).

9. Describing and presenting evidence and ideas

   Children will prepare tables, bar-graphs, line-graphs and drawings and they will be talking and writing in their own words.

⇩

MAKING USE OF SCIENTIFIC SKILLS AND IDEAS

10. Solving problems and making useful things

    For example,
    - (a) finding a fabric suitable for children's pyjamas;
    - (b) choosing an insulating material to make a picnic-box;
    - (c) making a fire-alarm;
    - (d) making a hot-air balloon.

PART II - DEVELOPING SCIENTIFIC IDEAS

Pupils will gradually change from thinking about the effects of heat to thinking about heat as a form of energy. Only when they can think about heat and how it affects materials can they develop an understanding of the movement of heat. By the age of 13 many children will still be thinking about what heat does rather than how it does it. Few will be able to grasp the distinction between heat and temperature.

	A	WHAT DOES HEAT DO?
CORE ideas are important scientific ideas which the majority of pupils can grasp, by the age of thirteen, in the form in which they are expressed here. They try to show the point reached by the majority of 13-year-olds on their journey towards understanding more formal scientific ideas. Most of the core ideas are patterns which pupils will see in their own practical activities, but there are some which cannot be presented practically and which therefore need verbal or audio-visual teaching; these are indicated by *. ● Indicates ideas which pupils have difficulty in grasping but which are so important that they are attempted in the middle years.	A1	Heat usually raises the temperature of materials.
	A2	Heat changes the appearance of many materials. Some materials, when they are cooled, do not appear as they did before they were heated. (Materials D1) (Air and Other Gases D9)
	A3	Some materials, when they are heated, start to burn and they can be used as fuels. (Materials D8) (Air and Other Gases D9)
	A4	The uses we can make of materials are decided by the way heat affects them. (Materials E1)
	A5	The world's supply of fuels is being used up. * (Materials E4)
	A6	Materials which are burning need oxygen, from the air, to burn in. (Air and Other Gases D7)
SUPPLEMENTARY ideas are no more difficult than core ideas, but they are less important.	A7	Heat makes some materials so hot that they glow.
	A8	Glowing materials glow brighter as they get hotter.
EXTENSION ideas are more difficult, abstract ideas which may be understood by pupils who have reached a later stage of conceptual development, characterised by abstract thinking.	*A9*	*The particles which make up a material move more vigorously when it is heated.*
	A10	*Heat is a form of energy.*
	A11	*Heat changes some materials permanently into new materials. It changes other materials only temporarily, changing the form of the material but not making a new material.*
	A12	*Although fossil fuels are still being formed, the world's supply of fuels is being used up much faster than it is being replenished.*

B HEATING AND COOLING SOLIDS

B1 Solids expand when they are heated and contract when they are cooled. The change may be too small for you to see. (Materials D3)

B2 When a solid is heated it eventually reaches a temperature at which it all melts to become a liquid. ●
(Materials D2)
(Water and Other Liquids D1)

B3 Some materials, especially metals, expand more than others for the same amount of heat.

B4 Every solid material has its own temperature for melting.

B5 When we heat a solid its particles move more vigorously and they take up more space. That is why a solid expands when it is heated.

B6 When a solid reaches its melting point its particles are moving so vigorously that they can no longer stay neatly packed together as a solid.

C HEATING AND COOLING GASES

(Children's understanding of the effects of heating and cooling gases will generally be limited to the example of air).

C1 Air expands when it is heated and contracts when it is cooled.
(Air and Other Gases B6)

C2 Hot air rises. ●
(Air and Other Gases B9)

C3 When steam is cooled it turns into liquid water. This process is called 'condensation'.
(Water and Other Liquids D2)

C4 Because hot air rises and cold air falls, currents, called convection currents, are set up in air.

C5 All gases take up more space when they are heated and less space when they are cooled.

C6 If it is cooled enough a gas will turn into a liquid.

C7 When a gas is heated its particles move more vigorously and each one moves in a bigger space. That is why a gas expands when it is heated.

C8 When a gas is heated, if its particles cannot move in a bigger space, they bump into one another more often and the gas's pressure increases.

D HEATING AND COOLING LIQUIDS

(Children's understanding of heating and cooling liquids will probably be limited to the case of water).

D1 When a liquid is heated its temperature rises and eventually it reaches a temperature at which it boils to become a gas.●
(Water and Other Liquids D2)

D2 A liquid expands when it is heated and contracts when it is cooled.
(Water and Other Liquids D4)

D3 Although cooling usually causes contraction, freezing water expands with such force as to break its container.
(Water and Other Liquids D4)

D4 When a liquid is boiling its temperature does not rise even though heating is continued.●
(Water and Other Liquids D7)

D5 When a liquid is cooled enough it will turn into a solid.
(Water and Other Liquids D1)

D6 When water is being heated, the hot water rises to the top and cooler water falls to the bottom.
(Water and Other Liquids D5)

D7 If you dissolve a substance in water then the freezing point and the boiling point of the water are changed.

D8 Like other liquids water contracts as it cools but it is unusual in that it expands as it is cooled from 4°C to 0°C.

D9 Every liquid has its own temperature, for turning into a solid, and this is called its freezing point. The temperatures are helpful in identifying liquids.

D10 Every liquid has its own boiling temperature. These temperatures are helpful in identifying liquids.

D11 As we heat a liquid, more of its particles escape from the surface to become vapour.

D12 A liquid boils when all the particles within it vibrate so vigorously that they escape from one another and become a gas.

D13 The boiling temperature of a liquid is affected by the pressure of the atmosphere. Where the pressure is lower, like at the top of a mountain, a liquid boils at a lower temperature than it does at sea level.

E MEASURING TEMPERATURE

E1 Thermometers are used to measure temperature. The height of liquid in a Thermometer is directly related to the temperature.

E2 We measure temperature in degrees centigrade (more correctly called celsius).

E3 0°C is the temperature of water freezing.
(Water and Other Liquids D3)

E4 100°C is the temperature of water boiling.
(Water and Other Liquids D3)

E5 37°C is the temperature of your body.

E6 20°C is the temperature of a warm room.

E7 Our skin cannot judge temperature accurately. (Sensitivity A6, D2)

E8 The liquids usually used in thermometers are mercury and alcohol.

E9 A thermometer tube is marked in degrees celsius, usually from -10°C to 110°C. But some thermometers have different ranges.

E10 Any material, which expands and contracts as it is heated and cooled, could be used to measure temperature.

E11 There are other kinds of thermometers. For example, electrical instruments which show temperature.

F DOES HEAT MOVE?

F1 When a metal is heated at one end the other end gets hot; pieces of other materials do not get hot at the other end. (Materials D5)

F2 Those materials which do not get hot all over when they are heated in one place are used to keep heat in. They are called 'insulators'. (Materials D5)

F3 Metals, which get hot all over when they are heated in one place, are called 'conductors'. (Materials D5)

F4 Wood, plastics and air are all insulators. (Materials D5)

F5 Metals feel cold to the touch. Most other materials do not. (Materials A3)

F6 The earth is warmed by heat from the sun.

F7 Air trapped in clothes, blankets, birds' feathers and animals' fur makes these good insulators. (Materials D6)

F8 Insulators are used to keep heat in or out. The lining of refrigerators, the jackets of hot-water tanks, and the fur of animals are examples of insulating materials.

F9 Heat will always move from a place which is at a higher temperature to one which is cooler.

F10 In gases and liquids heat is carried from place to place by movement of the heated substance.

F11 Hot gases or liquids rise because they are lighter than cold gases or liquids for the same volume. This movement of heat is called 'convection'.

F12 Heat moves through some solid materials. This is called 'conduction' of heat. Metals allow heat to move through them - they are good conductors of heat - but most solids and liquids and gases are poor conductors.

F13 Conductors of heat feel cold because they conduct heat away from your hand. Insulators feel warm because they do not conduct heat from your hand.

F14 Heat is conducted through a material because where the material is hotter its particles vibrate more vigorously and they bump into their neighbours so making them vibrate more vigorously too.

F15 Light-coloured or shiny surfaces reflect heat. Dark-coloured or dull surfaces absorb heat. This affects our use of colours and surfaces for different jobs.

G THREE STATES OF MATERIALS

G1 Water can exist as liquid water, solid ice or steam depending upon its temperature. (Water and Other Liquids A2, D1 and D2)

G2 A material becomes a solid, a liquid and then a gas as its temperature rises.

SAMPLE SCHEME OF WORK HEAT 9

Activities for pupils are listed below, together with references, as suggestions for teachers to consider in preparing an approach to this theme. These activities can be taken together or they can be used individually within other topics as shown in Section 5.2. Most of them will also contribute to core skills and ideas on other maps.

Activity	Reference	Skills Used *	Ideas Developing *	Year	*Minimum* Time Needed
Using fingers to feel warmth	Science 5/13, Ourselves, pages 41 - 42	1,2,3,4,6, 7,8,9	E7,F4,F5	1 or 2	½ hour overlapping with work on materials or senses
Keeping warm	Science 5/13, Early Experiences, page 67 Science 5/13, Children and Plastics, pages 18 - 20, 61 - 62 Science in a Topic, Clothes and Costume, page 24	1,2,3,4,5, 6,7,8,9,10	E1,E2,E6, E7,F7	1 or 2	1 hour
Looking at hot things	Science 5/13, Coloured Things, pages 59 - 61 Teaching Primary Science, Candles, pages 9 - 11, 21 Nuffield Combined Science Teachers' Guide I, pages 240 - 243 (Activity 6) and Activities 4 page 6	1,2,3,4,6, 7,8,9	A3,B2	1 or 2	½ hour
Watching what happens when water is heated	Nuffield Combined Science Teachers' Guide II, pages 19 - 21	3,4,6,7,8, 9	A1,D1,D4, D6,E4,E7, G1	3	1 hour overlapping with work on water
Finding out about water freezing	Nuffield Combined Science Teachers' Guide II, pages 21 - 22 Science 5/13, Change Stages 1 and 2, pages 49 - 51	1,3,4,6,7, 8,9	D3,D5,E3, G1	3	½ hour overlapping with work on water
Melting ice and boiling water	Nuffield Combined Science Teachers' Guide I, pages 170 - 171	1,3,4,6,7, 8,9	A2,B2,C3, D1,D4,D6, G1	3	2½ hours overlapping with work on water
Heating substances	Science 5/13, Change Stages 1 and 2, pages 51 - 52, 60 - 66 Nuffield Combined Science Teachers' Guide I, pages 156 - 162 and Activities 2, pages 43 - 47	1,2,3,4,6, 7,8,9	A2,A3,A4, B2	3	4 hours

/cont...

HEAT 9

Activity	Reference o	Skills Used *	Ideas Developing *	Year	*Minimum* Time Needed
Heating air	Nuffield Combined Science Teachers' Guide I, pages 240 - 243 (Activity 14 and 15) and Activities 4, pages 10 - 11	1,2,3,4,6, 7,8,9	C1,C2	3	1 hour overlapping with work on air
Investigating burning - finding out more about oxygen and nitrogen	Nuffield Combined Science Teachers' Guide I, pages 263 - 270	3,4,6,7,8, 9	A6	4	1 hour overlapping with work on air
Heating and cooling air, water and solids	Nuffield Combined Science Teachers' Guide II, pages 139 - 146 Science 5/13, Metals pages 44 - 45	1,2,3,4,6, 7,8,9	B1,C1,D2	4	1½ hours overlapping with work on air, water and materials
Looking for differences between metals and other materials in transferring heat	Nuffield Combined Science Teachers' Guide II, pages 217 - 220	1,2,3,4,6, 7,8,9	F1,F2,F3, F4,F5	4	1 hour overlapping with work on materials

o Details of references are given in Appendix 1

* Skills are listed by number with reference to the sequence of investigation techniques at the beginning of this map.

Ideas are listed by section and number with reference to the preceding pages. An activity may simply contribute to the development of an idea or it may be designed specifically to teach a particular idea.

☐ Pupils develop scientific ideas about light and colour by working like scientists on practical investigations.

☐ A practical science activity for pupils will usually give them the opportunity to work through the sequence of investigation techniques and to begin to develop scientific ideas.

☐ CORE SCIENCE is made up of both the techniques of investigating described below, and the emerging ideas which follow.

CORE SCIENCE STARTS HERE

⇩

PART I - INVESTIGATING

⇩

HAVING IDEAS

1. Making a start

   (a) Asking questions which can be answered by observing or experimenting

   For example, 'Which colours make good signs?' or 'Can we dye all fabrics?'

   or (b) Expressing ideas which can be put to the test

   For example, 'That colour will look black in red light'.

2. Planning observations, fair tests or controlled experiments, in small group discussion, individually or in a whole class

   For example, planning a test to find out whether a dye gives the same colour with different fabrics.

⇩

COLLECTING EVIDENCE

3. Making observations, either directly or from experiments, and measuring when it is appropriate

   (a) observing changes in colour when paints or inks are mixed;

   (b) observing the effects of coloured lights on coloured things;

   (c) observing images in a wide variety of lenses, mirrors, and other transparent or reflecting objects including water drops on surfaces;

   (d) observing colours in nature, looking for links with animals' or plants' way of life.

HANDLING EVIDENCE

4. Recording

   Making tables, bar-graphs or charts to record observations.

5. Calculating

   There are many calculations which children can make from their measurements but none which is a core skill within this theme.

6. Talking in small groups or as a whole class, children will explore and develop their own ideas about their experiences.

7. Trying to classify, order and look for patterns

   (a) sorting materials into transparent and opaque materials;

   (b) sorting mirrors and lenses according to the kind of image they produce;

   (c) sorting bright things into those which make their own light and those which just reflect light.

   (The patterns which pupils will see in their observations follow as scientific ideas). →

8. Trying to explain in terms of cause and effect

   For example, 'The bunsen-burner flame turns yellow when we close the hole, because air can't get in'.

   (Explanations of a more sophisticated kind follow as extension ideas). →

9. Describing and presenting evidence and ideas

   Children will prepare tables, bar-graphs and drawings and they will be talking and writing in their own words.

⇩

MAKING USE OF SCIENTIFIC SKILLS AND IDEAS

10. Solving problems and making useful things

    For example,

    (a) finding out whether car safety is affected by colour;

    (b) designing safety clothing for cyclists and pedestrians;

    (c) making a good sign for warning in fog;

    (d) making a football to be seen in poor light;

    (e) making a periscope to see over obstacles.

PART II - DEVELOPING SCIENTIFIC IDEAS

A LIGHT AND SEEING

CORE ideas are important scientific ideas which the majority of pupils can grasp, by the age of thirteen, in the form in which they are expressed here.

They try to show the point reached by the majority of 13-year-olds on their journey towards understanding more formal scientific ideas.

Most of the core ideas are patterns which pupils will see in their own practical activities, but there are some which cannot be presented practically and which therefore need verbal or audio-visual teaching; these are indicated by *.

● indicates ideas which pupils have difficulty in grasping but which are so important that they are attempted in the middle years.

(Pupils will begin by thinking of seeing as something they do with their eyes. (See also Sensitivity - Section C). Gradually pupils will be encouraged to interpret seeing in terms of what light is doing but many pupils have difficulty in explaining experiences in terms of light beams).

A1 Some things produce light but most things do not.

A2 We can see things because light comes from them to our eyes. * ● (Sensitivity C1)

A3 Some materials let light pass through and so we can see through them. ●

A4 Materials through which we can see clearly are called 'transparent'. *

A5 Some materials do not let light pass through and so we cannot see through them. ●

A6 Materials which we cannot see through are called 'opaque'. *

A7 When you look in a mirror, you see a reflection.

A8 When you see a reflection in a mirror it is always 'back-to-front'.

A9 The best reflections can be seen in shiny surfaces.

A10 Objects dipping into water may look bent.

A11 Objects seen through materials which are not flat look a different shape.

A12 When light shines on one side of opaque materials there is a shadow on the side away from the light.

SUPPLEMENTARY ideas are no more difficult than core ideas, but they are less important.

A13 As the sun moves across the sky the shadow cast by a sundial changes direction and this can be used to tell the time.

A14 When we look into water it never looks as deep as it actually is.

EXTENSION ideas are more difficult, abstract ideas which may be understood by pupils who have reached a later stage of conceptual development, characterised by abstract thinking.

A15 Light beams travel in straight lines.

A16 The angle at which a beam of light strikes a straight mirror is the same as the angle at which it is reflected away.

A17 When a beam of light passes through a transparent material its direction may be changed.

A18 Objects dipping into water may look bent, or objects in water may look nearer the surface than they really are, because light travelling from objects underwater to our eyes changes direction at the surface of the water.

B OPTICAL AIDS

B1 Lenses are made from transparent material. They are made with specially curved surfaces.

B2 When we look through a lens we may see things smaller, or larger, or even upside down, depending on the shape of the lens.

B3 Instruments can be made, using lenses and mirrors, which help us to see things better.

B4 Curved mirrors may make things look larger or smaller, or even upside down.

B5 We can use lenses and mirrors mounted together to magnify things very greatly or to make things look smaller.

B6 A camera lens produces a sharp picture on photographic film.

B7 A telescope, or binoculars, are made to magnify things which are a long way away.

B8 If a person cannot see clearly we can make lenses which help.

B9 We can use curved mirrors as magnifiers, for example in a shaving mirror.

B10 We can use curved mirrors to reflect a very wide view as for example in the wing mirror of a car.

B11 A periscope uses mirrors to enable us to see over or around objects.

B12 Convex lenses make rays of light converge.

B13 Concave lenses make rays of light diverge.

B14 Convex mirrors make rays of light diverge.

B15 Concave mirrors make rays of light converge.

C COLOURED PAINTS

(Ideas about mixing paint colours will arise from work in art).

C1 Many coloured substances are made up of several colours mixed together.

C2 Red, blue and yellow are the colours from which we can make all other colours.

C3 Red and blue pigments mix to give a purple pigment.

C4 Red and yellow pigments mix to give an orange pigment.

C5 Blue and yellow pigments mix to give a green pigment.

C6 We can separate the coloured substances from a mixture of colours by letting them spread apart on absorbent material like cloth, newspeper or filter paper. We call this 'chromatography'.

C7 Opaque coloured materials only reflect back their own colour of light from the white light falling on them. They absorb all the other colours.

C8 Red, blue and yellow paints together absorb all the colours from white light. No colour is reflected from the mixture and the mixture looks black.

C9 A white material reflects all the colours from white light and absorbs none.

D	LIGHT, COLOUR AND LIVING THINGS	E	DYES
D1	An animal's colour is one of the ways in which it may be fitted to its environment. (Variety and Adaptation C1)		
D2	The bright colour of many plants attracts the insects which are needed to pollinate the flowers.	E1	Dyes are substances which can be made to colour fabrics.
D3	The colour of some animals is very striking at mating time and it helps to attract a partner.	E2	Some dyes will only work with particular fabrics.
D4	Some animals can change colour.	E3	Many of the coloured substances in flowers, leaves and roots can be used as dyes, but most of the dyes used now are man-made from other substances.
D5	Plants grow towards the strongest source of light. This results in leaves spreading on a tree so that they shade one another as little as possible.	E4	The coloured dyes in some plants, for example the red in red cabbage, change colour when they contact acids or bases (alkalis). These pigments can be used as indicators to show whether substances are acidic or alkaline.
		E5	We can use bleach to 'remove' some dyes from fabrics.
		E6	Washing may remove some dyes from fabrics.
		E7	Light removes the colour of some dyes; we call this 'fading'.
D6	*Plants grow slower in the light than they do in the dark but if they are left in darkness the leaves lose their green colour and the plants eventually die.*	*E8*	*When we remove a colour by bleaching the dye is not removed but simply changed by the bleach.*
D7	*When a seed germinates the shoot grows towards light and away from the earth.*		

F	COLOURED LIGHT	G	DAYLIGHT
F1	Sunlight is made up of all the colours of the rainbow.	G1	The earth gets its light from the sun. (The Earth in the Universe C1, E2)
F2	When sun shines through rain drops it makes a rainbow.	G2	We have daylight when our side of the earth is facing the sun, and we have darkness when our side of the earth has moved away from the sun. (The Earth in the Universe E5)
F3	We call the series of colours in a rainbow 'the spectrum'. *		
F4	When light shines through a prism it may be split into the colours of the spectrum.		
F5	Coloured lights can make coloured things appear a different colour.		
F6	Red and blue light together make magenta or purple coloured light.	G3	At the equator the length of day is the same all the year round.
F7	Red and green light together make yellow light.	G4	At the North and South poles there is a time of the year when there is no daylight and a time of year when there is no darkness.
F8	Green and blue light together make turquoise or peacock blue light.	G5	Many plants, including trees, develop flowers when the days get longer in the spring.
F9	Red, blue and green light are called the 'primary' light colours.	G6	When days become shorter some trees start losing their leaves.
F10	*The colours of a rainbow can be combined to give white light.*	*G7*	*The earth's axis is tilted so that in part of the year the Northern hemisphere leans towards the sun and in part of the year the Southern hemisphere leans towards the sun. This causes the longer days or shorter days of summer and winter.*
F11	*A rainbow is formed when drops of water act like glass prisms and each splits white light into all its colours.*	*G8*	*Because the earth's axis is tilted, the poles have periods of constant darkness.*
F12	*Particles on the back of a colour television screen are made to give out red, blue or green light when the set is switched on. The three lights produce the other colours on the screen.*	*G9*	*The length of day acts as the main 'switch' in causing changes in plants such as flowering or leaf-fall. The amount of water available and the temperature also play a part.*
F13	*Transparent coloured materials allow only their own colour of light to pass through and they absorb all the other colours from white light.*		

Activities for pupils are listed below, together with references, as suggestions for teachers to consider in preparing an approach to this theme. These activities can be taken together or they can be used individually within other topics as shown in Section 5.2. Most of them will also contribute to core skills and ideas on other maps.

Activity	Reference o	Skills Used *	Ideas Developing *	Year	Minimum Time Needed
Learning to look	Science 5/13, Using the Environment 1 Early Explorations, pages 6 - 14 Science 5/13, Early Experiences, page 73	1,2,3,4,6, 7,8,9	A1,A2,A3, A4,A5,A6, A11,A12	1 or 2	2 hours overlapping with work in sensitivity
Looking for reflections	Science 5/13, Using the Environment 1 Early Explorations, page 16 Science 5/13, Early Experiences, pages 74 - 78 Teaching Primary Science, Mirrors and Magnifiers	1,2,3,4,6, 7,8,9,10	A7,A8,A9, A10,B3	1 or 2	1½ hours
Making shadows	Science 5/13, Early Experiences, pages 5 - 13	1,2,3,4,5, 6,7,8,9,10	A5,A6,A12, G1,G2	1 or 2	1 hour overlapping with work on the earth in the universe
Mixing paints	Science 5/13, Coloured Things, page 14	1,2,3,4,6, 7,8,9,10	C1,C2	1 or 2	1 hour
Looking for colour in plants and animals	Science 5/13, Coloured Things, pages 19 - 30	1,2,3,4,6, 7,8,9,10	D1	2	2 hours overlapping with with work on variety and adaptation
Using coloured light	Science 5/13, Coloured Things, pages 14 - 17 Science 5/13, Using the Environment 1 Early Explorations, page 15	1,2,3,4,6, 7,8,9,10	F1,F2,F3, F4,F5	2	1 hour
Using lenses and curved mirrors	Science 5/13, Early Experiences, pages 73 - 74, 76 Teaching Primary Science, Mirrors and Magnifiers	1,2,3,4,6, 7,8,9,10	B1,B2,B3 B4	2	2 hours

o Details of references are given in Appendix 1

* Skills are listed by number with reference to the sequence of investigation techniques at the beginning of this map.

Ideas are listed by section and number with reference to the preceding pages. An activity may simply contribute to the development of an idea or it may be designed specifically to teach a particular idea.

☐ Pupils develop scientific ideas about sound by working like scientists on practical investigations.

☐ A practical science activity for pupils will usually give them the opportunity to work through the sequence of investigation techniques and to begin to develop scientific ideas.

☐ CORE SCIENCE is made up of both the techniques of investigating described below, and the emerging ideas which follow.

CORE SCIENCE STARTS HERE

⇩

PART I - INVESTIGATING

⇩

HAVING IDEAS

1. Making a start

   (a) Asking questions which can be answered by observing or experimenting

   For example, 'Can we change the sound which an object, or an instrument, makes?'

   or (b) Expressing ideas which can be put to the test

   For example, 'Tightening a string makes a higher sound' or 'Using a longer string makes a lower sound'.

2. Planning observations, fair tests or controlled experiments, in small group discussion, individually or in a whole class

   For example, planning to investigate the changes caused by varying length, thickness or tension of a wire or string.

⇩

COLLECTING EVIDENCE

3. Making observations, either directly or from experiments, and measuring when it is appropriate

   (a) feeling and looking at vibrating objects, trying to relate loudness of sound to size of vibration;

   (b) making and listening to a variety of different sounds, listening for loudness, pitch and tone (quality) of sounds. Pupils will use tuning-forks, a variety of stringed instruments, different solid materials, home-made musical instruments. They will use pulleys, clamps and slotted masses to vary the tension in strings or wires;

   (c) measuring the length of strings or wires and measuring tension in strings by noting loads applied for stretching.

HANDLING EVIDENCE

4. Recording

   Making tables, bar-graphs or charts to record observations.

5. Calculating

   There are many calculations which children could make from their measurements but none which is a core skill within this theme.

6. Talking in small groups or as a whole class, children will explore and develop their own ideas about their experiences.

7. Trying to classify, order and look for patterns

   (a) sorting materials into those you can hear through and those you can't hear through very well;

   (b) putting sounds in order of loudness;

   (c) sorting musical instruments into groups according to how they make sounds.

   (The patterns which pupils will see in their observations follow as scientific ideas).

8. Trying to explain in terms of cause and effect

   For example, 'The sound became higher because we shortened the string'. (More sophisticated ideas follow as extension ideas).

9. Describing and presenting evidence and ideas

   Children will prepare tables, bar-graphs or charts and they will be talking and writing in their own words.

MAKING USE OF SCIENTIFIC SKILLS AND IDEAS

10. Solving problems and making useful things

    For example,

    (a) making sound travel further;

    (b) making sounds louder;

    (c) designing a sound-proof room;

    (d) making musical instruments;

    (e) making a field-telephone.

PART II - DEVELOPING SCIENTIFIC IDEAS

	A MAKING SOUNDS
Core ideas are important scientific ideas which the majority of pupils can grasp, by the age of thirteen, in the form in which they are expressed here. They try to show the point reached by the majority of 13-year-olds on their journey towards understanding more formal scientific ideas. Most of the core ideas are patterns which pupils will see in their own practical activities, but there are some which cannot be presented practically and which therefore need verbal or audio-visual teaching; these are indicated by *. ● indicates ideas which pupils have difficulty in grasping but which are so important that they are attempted in the middle years.	A1 Sound is made when things vibrate. Sometimes it is easy to see the vibration. (Sensitivity E6) A2 You can tell the difference between sounds made by different things without seeing what makes the sound. (Sensitivity E3) A3 Sounds can vary in loudness. (Sensitivity E3) A4 Sounds can vary in pitch. There are high notes and low notes. (Sensitivity E3)
SUPPLEMENTARY ideas are no more difficult than core ideas, but they are less important.	A5 Music is made up from sounds chosen to sound pleasant together. A6 When we make sounds with our voices we make our vocal cords vibrate in our throats.
EXTENSION ideas are more difficult, abstract ideas which may be understood by pupils who have reached a later stage of conceptual development, characterised by abstract thinking.	*A7 A sound has three characteristics: loudness, pitch and tone from which we can tell what is making the sound.*

B	LOUDNESS	C	PITCH
B1	A bigger vibration makes a louder sound.	C1	A string makes a higher sound if it is shorter or tighter.
		C2	A drum makes a higher sound if its skin is tighter.
		C3	Tuning forks are made so that when they vibrate they produce a particular note.
		C4	We tune instruments so that they make the particular notes we want.
B2	We have developed electrical 'amplifiers' which can make sounds louder.	C5	A bottle or a pipe makes a higher note when there is less air space inside.
		C6	'Middle C' tuning forks vibrate back and forth 256 times every second.
		C7	The C above 'Middle C' vibrates 512 times every second.
B3	*A bigger vibration causes more movement in the surrounding air and our ears hear this as a louder sound.*	*C8*	*A faster vibration gives a higher pitched sound.*
B4	*If we show sound as waves drawn on paper, then loudness is represented by the height of the waves. A higher wave represents a louder sound.*	*C9*	*Tuning forks are specially made to vibrate at definite rates so that they make particular sounds.*
B5	*When we draw a sound wave on paper the top of the wave is called its 'crest' and the lowest part is called its 'trough'.*	*C10*	*We tune instruments to make them vibrate at the right rate to make the notes we want.*
B6	*As sound travels its vibration gradually decreases and becomes less energetic. Therefore the second dies away.*		

D	HEARING SOUNDS	E	TRANSMITTING SOUND
D1	For a sound to be heard it must reach our ears. *	E1	Sound travels through air and through other materials.
D2	Sounds which are very loud can permanently damage ears. * (Sensitivity E1)	E2	Sound must have something to travel through. * ●
D3	If a sound is further away it seems to be softer.	E3	Some materials allow sound to travel through them better than others.
D4	A louder sound can be heard a longer distance away.	E4	Sound takes time to travel.
D5	When sounds are unpleasant we call them 'noise'. This can be so disturbing that we talk of 'noise pollution'. (Sensitivity E2)	E5	Materials which do not let sound pass through them very easily can be used as insulators to keep sound in or out.
D6	Some sounds are either too low-pitched for us to hear. Bats and moths make a high-pitched sound which we cannot hear.	E6	Theatres and concert halls need walls which are made of materials which do not give echoes.
D7	We have developed special 'hearing aids' for people who cannot hear well of their own accord.	E7	When sound bounces back from a surface, then we hear the sound again and we call it an echo.
D8	Hearing is very important for a young child learning to talk. A child who has poor hearing may pronounce words wrongly.	E8	Echoes are used by animals to 'see' in the dark. For example, the echoes of the high-pitched sounds made by bats and moths tell them about their surroundings.
		E9	Echoes are used to detect shoals of fish or submarines, and to work out the depth of the sea bed.
		E10	We have developed electrical devices for transmitting sound further than it would go of its own accord.
		E11	Thunder is the sound arising from a lightning flash. We see lightning before we hear the sound from it.
D9	*Very slow vibrations or very fast vibrations are not recognised as 'sounds'.*	*E12*	*Sound waves travel through air and through other materials.*
		E13	*Sound cannot travel through a vacuum.*
		E14	*Light travels faster than sound does and so we see things before we hear them if they are a long way away.*

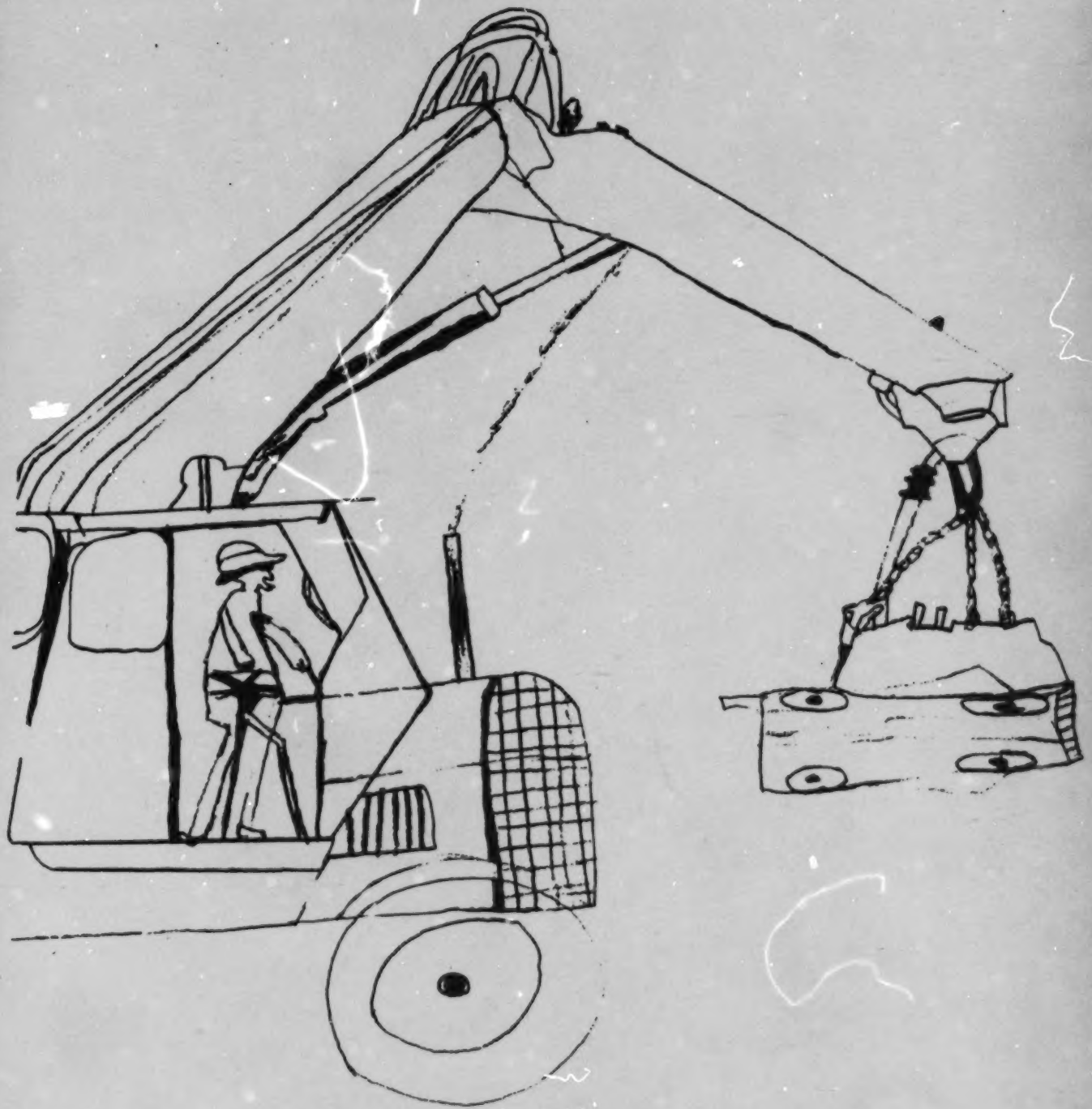
Activities for pupils are listed below, together with references, as suggestions for teachers to consider in preparing an approach to this theme. These activities can be taken together or they can be used individually within other topics as shown in Section 5.2. Most of them will also contribute to core skills and ideas on other maps.

Activity	Reference o	Skills Used *	Ideas Developing *	Year	Minimum Time Needed
Listening to sounds and making sounds	Science 5/13, Using the Environment 1 Early Explorations, pages 25 - 27 Science 5/13, Early Experiences, pages 31 - 33 Science 5/13, Ourselves, pages 22 - 24	1,2,3,4, 6,7,8,9,10	A2,A3,D3, D4,D5	1 or 2	1 hour overlapping with work on the senses
Making musical instruments	Science 5/13, Early Experiences, pages 33 - 35 Science 5/13, Science from Toys, pages 11 - 15	1,2,3,4,6, 7,8,9,10	A2,A3,A4, C1,C2,C3, C4	1 or 2	2 hours
Finding out what makes a sound	Science 5/13, Early Experiences, page 33	1,2,3,4,6, 7,8,9,	A1,B1,D1, D3,D4	2	1 hour
Finding out how sound travels	Science 5/13, Early Experiences, pages 36 - 37, 39	1,2,3,4,6, 7,8,9,10	E1,E2,E3, E4,E5	2 or 3	1 hour

o Details of references are given in Appendix 1

* Skills are listed by number with reference to the sequence of investigation techniques at the beginning of this map.

Ideas are listed by section and number with reference to the preceding pages. An activity may simply contribute to the development of an idea or it may be designed specifically to teach a particular idea.



☐ Pupils develop scientific ideas about magnets and magnetism by working like scientists on practical investigations.

☐ A practical science activity for pupils will usually give them the opportunity to work through the sequence of investigation techniques and to begin to develop scientific ideas.

☐ CORE SCIENCE is made up of both the techniques of investigating described below, and the emerging ideas which follow.

CORE SCIENCE STARTS HERE

⇩

PART I - INVESTIGATING

⇩

HAVING IDEAS

1. Making a start

   (a) Asking questions which can be answered by observing or experimenting

   For example, 'Are all metals attracted to a magnet?'

   or (b) Expressing ideas which can be put to the test

   For example,'A big magnet is a strong magnet' or 'A big magnet can be a weak magnet'.

2. Planning observations, fair tests or controlled experiments, in small group discussion, individually or in a whole class

   For example, planning a fair test of the strength of different-sized magnets.

⇩

COLLECTING EVIDENCE

3. Making observations, either directly or from experiments, and measuring when it is appropriate

   (a) feeling the pull of a variety of magnets, or different strengths, on magnetic materials;

   (b) feeling the pushes and pulls between the poles of magnets;

   (c) observing the patterns of iron filings around a magnet;

   (d) using a magnetic compass to find direction and to test whether an object is a magnet or not;

   (e) using a copper coil with a soft iron core to make an electro-magnet.

HANDLING EVIDENCE

4. Recording

   Making tables or charts to record observations.

5. Calculating

   There are no calculations which are core skills within this theme.

6. Talking in small groups or as a whole class, children will explore and develop their own ideas about their experiences.

7. Trying to classify, order and look for patterns

   (a) sorting materials into those which are magnetic and those which are non-magnetic;

   (b) sorting magnetic materials into those which have been magnetised (magnets) and those which have not.

   (The patterns which pupils will see in their observations follow as scientific ideas). →

8. Trying to explain in terms of cause and effect

   For example, 'This piece of metal is attracted to the magnet because it is iron or steel'.

   (Explanations of a more sophisticated kind follow as extension ideas). →

9. Describing and presenting evidence and ideas

   Children will prepare tables, charts or drawings and they will be talking and writing in their own words.

⇩

MAKING USE OF SCIENTIFIC SKILLS AND IDEAS

10. Solving problems and making useful things

    For example,

    (a) trying to find a way of shielding something from a magnet's force;

    (b) designing a measuring device to measure the strength of magnets;

    (c) devising a way of sorting aluminium cans from steel cans for recycling.

PART II - DEVELOPING SCIENTIFIC IDEAS

Pupils will gradually change from thinking about magnets to thinking about the force, magnetism, although it may be that many pupils do not take this step by the age of 13.

	A MAGNETIC MATERIALS
CORE ideas are important scientific ideas which the majority of pupils can grasp, by the age of thirteen, in the form in which they are expressed here. They try to show the point reached by the majority of 13-year-olds on their journey towards understanding more formal ideas. Most of the core ideas are patterns which pupils will see in their own practical activities, but there are some which cannot be presented practically and which therefore need verbal or audio-visual teaching; these are indicated by *. ● indicates ideas which pupils have difficulty in grasping but which are so important that they are attempted in the middle years.	A1 Materials can be sorted into two sets: those which are attracted to a magnet, magnetic materials; and those which are not non-magnetic materials. A2 Iron and some kinds of steel are the magnetic materials we are most likely to meet. (Materials A5) A3 Most common metals such as copper, lead, zinc, silver are non-magnetic. A4 Plastics and wood are examples of non-magnetic materials.
SUPPLEMENTARY ideas are no more difficult than core ideas, but they are less important.	
EXTENSION ideas are more difficult, abstract ideas which may be understood by pupils who have reached a later stage of conceptual development, characterised by abstract thinking.	*A5 All metals which contain iron, cobalt or nickel are magnetic.*

B	MAKING MAGNETS	C	THE EARTH'S MAGNETISM
B1	Magnets occur naturally in the earth. *	C1	A bar magnet can be suspended or pivoted and used as a compass to show the direction of North.
B2	A magnet has been made from magnetic material. You can't make a magnet from non-magnetic material.	C2	The earth has its own magnetic force acting all around it and it behaves like a magnet: that is why a compass needle points to the North.
B3	A magnet loses its magnetism if it is dropped, banged or heated. *		
B4	Magnets may be bar shaped, ring shaped, horse-shoe shaped, button shaped.		
B5	A magnet can be made by stroking magnetic material with a magnet, or even by leaving magnetic material beside a magnet for some time.		
B6	Electricity can be used to make magnetic material into a magnet. (Electricity F8)		
B7	When electricity flows in a coil of wire wrapped around a soft iron core, the iron becomes magnetised whilst the current is switched on. (Electricity F9)		
B8	Magnets occur naturally as magnetite. This is also called 'lodestone' from the Anglo-Saxon word meaning 'leading stone'.	C3	The earth has magnetic North and South poles.
B9	Little bars of magnetic material called 'keepers' are used to link the ends of magnets when they are stored. Keepers help to stop magnets losing their magnetism.	C4	A magnet which is swinging freely has its North pole dipping towards the ground.
B10	When magnetic material is attracted to a magnet it behaves like a magnet.		
B11	Some kinds of iron or steel stay magnetised after they have been near to a magnet, but others only behave like a magnet whilst they are in touch with the magnet.		
B12	*The tiny particles which make up magnetic materials are all tiny magnets which can be pulled into line so that they all lie in the same direction.*		
B13	*When a magnetic material is attracted to a magnet there is lining up of the particles in the magnetic material.*		
B14	*A magnet is magnetic material in which all the tiny particle magnets are pointing in the same direction. They can be pulled into line by another magnet or by the field created by an electric current.*		
B15	*When a magnet is dropped or heated the lining up of the particles is disturbed and the magnet is weakened.*		

D WHAT WILL MAGNETS DO?

(Strictly speaking the North pole of a magnet is the 'North-seeking' pole: by convention that which seeks the North of the earth. This is usually abbreviated and it may be that an able pupil will question the North pole of a magnet being attracted to the North pole of the earth).

D1 A magnet picks up small bits of magnetic materials such as iron and steel.

D2 Magnets produce a force which we call 'magnetism'.
(Movement, Forces and Structures B5)

D3 The pull of a magnet is felt more strongly near its ends.

D4 The ends of a magnet are not alike. We call one end the North pole and the other end the South pole. *

D5 Two similar poles, two North poles or two South poles, will push one another apart but two poles which are different are attracted to one another.

D6 We never get a North pole without a South pole opposite.

D7 When you sprinkle iron filings around a magnet you can see a pattern.

D8 The region around a magnet in which the magnet's force is felt is called the 'magnetic field'. *

D9 The force, which a magnet exerts all round it, passes through most materials.

D10 A magnet doesn't need to touch a piece of magnetic material before it can pull it, but the material has to be in a magnet's 'field'.
(Movement, Forces and Structures A7)

D11 A compass needle is a free-moving magnet and it is used to find direction.

D12 The strength of a magnet cannot be judged by its size. A small magnet may be strong and some large magnets are weak.

D13 Iron filings sprinkled around two magnets show how the magnets' forces act between the ends of the magnets.

D14 Permanent magnets or electromagnets are used in electric bells, telephones, electric motors, dynamos, power stations, television sets.

D15 The tiny particles of a magnet each have a North and a South pole.

D16 A magnet exerts a force all around it. The force passes through empty space, as well as through most materials and it is this force which draws iron filings into a pattern.

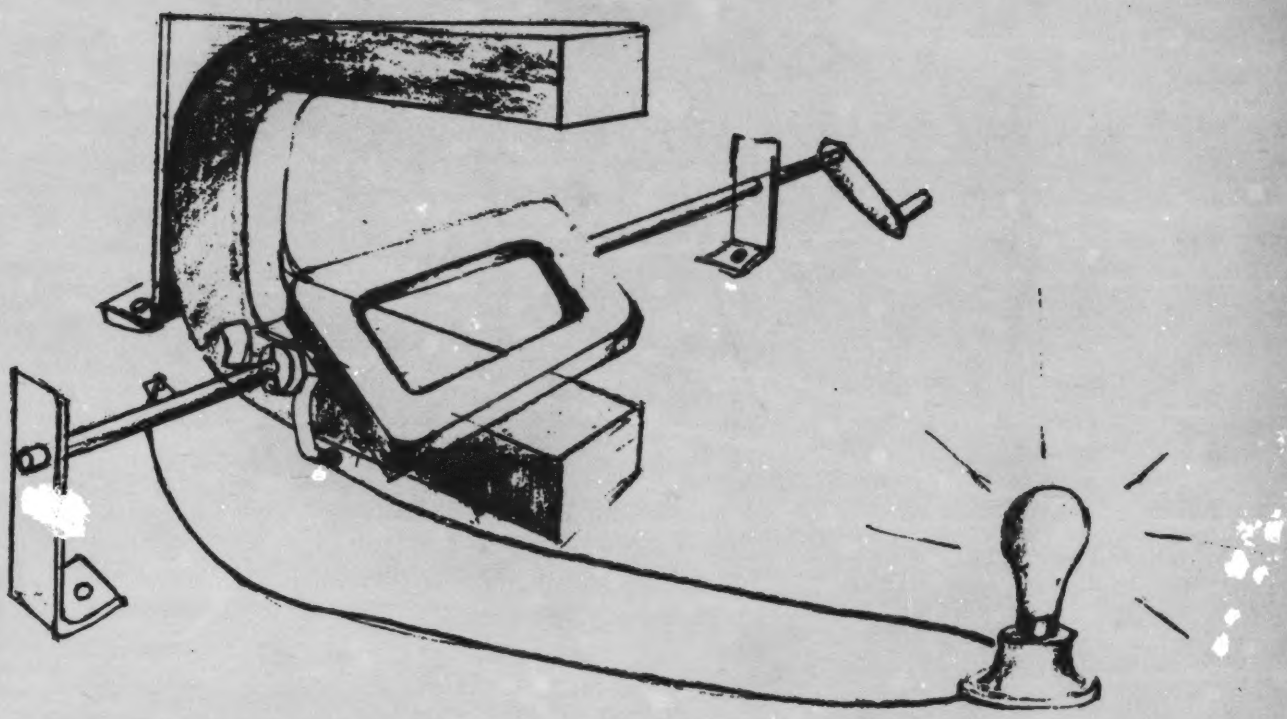
Activities for pupils are listed below, together with references, as suggestions for teachers to consider in preparing an approach to this theme. These activities can be taken together or they can be used individually within other topics as shown in Section 5.2. Most of them will also contribute to core skills and ideas on other maps.

Activity	Reference o	Skills Used *	Ideas Developing *	Year	*Minimum* Time Needed
Finding out which materials are attracted to a magnet	Science 5/13, Metals Stages 1 and 2, pages 21 - 22	3,4,6,7,8, 9,10	A1,A2,A3, A4,B4,D1, D3,D10, D12	1 or 2	1 hour overlapping with work on materials
Making a magnet	Science 5/13, Metals Stages 1 and 2, page 22	1,2,3,4,6, 7,8,9,10	B2,B5,C1	1 or 2	½ hour
Finding out whether magnets can act through materials	Science 5/13, Metals Stages 1 and 2, page 22	1,2,3,4,6, 7,8,9,10	D9,D10	1 or 2	½ hour
Examining a magnet	Explore and Discover, page 264	3,4,6,7,8, 9	D1,D2,D3, D7,D10	1 or 2	½ hour
Finding the North-pole of a magnet and using a plotting compass	Explore and Discover, pages 264 - 265	1,3,4,6,7, 8,9,10	C1,C2	3	½ hour
Finding out how magnets affect one another	Explore and Discover, page 265	1,2,3,4,6, 7,8,9	D2,D3,D4, D5,D6,D8, D12	3	½ hour
Investigating the link between electricity and magnetism	Nuffield Combined Science Teachers' Guide I, pages 332 - 337 Science 5/13, Metals Stages 1 and 2, page 48 New Unesco Source Book for Science Teaching, page 102	3,4,6,7,8, 9,10	B6,B7	4	1 hour overlapping with work on electricity
Making a current balance	Nuffield Combined Science Teachers' Guide I, pages 327 - 332	3,4,6,7,8, 9,10	B7	4	1 hour

o Details of references are given in Appendix 1

* Skills are listed by number with reference to the sequence of investigation techniques at the beginning of this map.

Ideas are listed by section and number with reference to the preceding pages. An activity may simply contribute to the development of an idea or it may be designed specifically to teach a particular idea.



☐ Pupils develop scientific ideas about electricity by working like scientists on practical investigations.

☐ A practical science activity for pupils will usually give them the opportunity to work through the sequence of investigation techniques and to begin to develop scientific ideas.

☐ CORE SCIENCE is made up of both the techniques of investigating described below, and the emerging ideas which follow.

CORE SCIENCE STARTS HERE

⇩

PART I - INVESTIGATING

⇩

HAVING IDEAS

1. Making a start

   (a) Asking questions which can be answered by observing or experimenting

   For example, 'Do batteries work just as well whichever way we put them in a circuit?' or 'Which materials allow electricity to pass through them?'

   or (b) Expressing ideas which can be put to the test

   For example, 'Adding another battery will make the bulb brighter'.

2. Planning observations, fair tests or controlled experiments, in small group discussion, individually or in a whole class

   For example, planning an experiment to find out if all metals conduct electricity equally well.

⇩

COLLECTING EVIDENCE

3. Making observations, either directly or from experiments, and measuring when it is appropriate

   (a) observing the brightness of bulbs in different circuits, using the brightness of the bulb as a rough indicator of 'amount' of electricity;

   (b) using bulbs, batteries, wires or connectors and switches to make a variety of different circuits;

   (c) using an ammeter as a 'black-box' to measure 'amount' of electricity;

   (d) using the following symbols in circuit diagrams in building and describing circuits: bulb Ⓜ ; cell ⊣⊢ ;
   wire or connector —— ; key/switch —/— ; ammeter Ⓐ .

HANDLING EVIDENCE

4. Recording
   (a) using tables to record observations and measurements;
   (b) using symbols in circuit diagrams to record circuits which have been made.

5. Calculating
   There are calculations which pupils can make from their measurements but none which is a core skill within this theme.

6. Talking in small groups or as a whole class, children will explore and develop their own ideas about their experiences.

7. Trying to classify, order and look for patterns
   (a) sorting materials into good conductors and poor conductors;
   (b) recognising circuits as either 'series' or 'parallel' circuits.
   (The patterns which pupils will see in their observations follow as scientific ideas). →

8. Trying to explain in terms of cause and effect
   For example, 'The bulb is brighter because we used two batteries instead of one'.
   (Explanations of a more sophisticated kind follow as extension ideas). →

9. Describing and presenting evidence and ideas
   Children will prepare tables, charts, diagrams, or drawings and they will be talking and writing in their own words.

⇩

MAKING USE OF SCIENTIFIC SKILLS AND IDEAS

10. Solving problems and making useful things
    (a) wiring a three-pin plug;
    and other problems, for example;
    (b) making three bulbs operate independently, from one battery;
    (c) making a burglar-alarm or a fire-alarm;
    (d) inventing quiz games with electrical feedback.

PART II - DEVELOPING SCIENTIFIC IDEAS

	A MAKING A SIMPLE CIRCUIT
CORE ideas are important scientific ideas which the majority of pupils can grasp, by the age of thirteen, in the form in which they are expressed here. They try to show the point reached by the majority of 13-year-olds on their journey towards understanding more formal scientific ideas. Most of the core ideas are patterns which pupils will see in their own practical activities, but there are some which cannot be presented practically and which therefore need verbal or audio-visual teaching; these are indicated by *. ● indicates ideas which pupils have difficulty in grasping but which are so important that they are attempted in the middle years.	A1 A complete metal pathway is needed for electricity to flow through. A2 The complete pathway for electricity is called a 'circuit'. * A3 Electricity will not go along a dead-end side path in a circuit. A4 A simple circuit consists of a battery, a bulb and wire connectors. A5 We must make a gap in the circuit to 'switch' the electricity off. A6 Bulbs are designed to work with a battery of a particular voltage. * A7 If we use a battery which is too powerful for the bulb, then the bulb will blow and not work any more. *
SUPPLEMENTARY ideas are no more difficult than core ideas, but they are less important.	A8 A blown bulb has not got a complete wire pathway inside because the wire in the bulb has melted.
EXTENSION ideas are more difficult, abstract ideas which may be understood by pupils who have reached a later stage of conceptual development, characterised by abstract thinking.	*A9 A complete conducting pathway is necessary for electricity to flow. Some materials other than metals are conductors which can be part of an electrical circuit.*

B MEASURING ELECTRICITY

B1 A bulb in a circuit can be used to detect electricity.

B2 The brightness of a bulb shows how much electricity is flowing in a circuit.

B3 An ammeter can be used to measure electricity in a circuit.

B4 We use a voltmeter to measure, in volts, the 'pushing power' of a battery and also to measure the voltage difference between any two points in a circuit.

B5 A weak current may be flowing in a circuit without lighting the bulb.

B6 An ammeter is a measuring instrument which uses the pull on a magnet to measure an electric current. Inside an ammeter is a magnet and a coil of wire and one of these moves when electricity flows through the wire.

B7 In a parallel circuit an ammeter will only measure the current flowing in the loop in which it is placed; it will only measure the total electricity flowing if it is placed so that all the electricity flows through it.

B8 Electricity can be thought of as a flow of tiny particles, called 'electrons', that can move through a solid wire in much the same way as water travels through a pipe.

C BATTERIES

(Although many pupils will know that a battery consists of several cells, most will probably use the words 'battery' and 'cell' indiscriminately.)

C1 A battery has a positive end and a negative end.

C2 When only one battery is used in a circuit the light remains the same if you turn the battery the other way round. A bulb lights regardless of the way the battery points.

C3 If two batteries are used, connected positive to negative in a circuit, then the bulb is brighter than it would be with one battery.

C4 If two batteries are used, connected positive to positive or negative to negative in a circuit, then the batteries work against one another and the bulb may not light.

C5 The job of the battery in a circuit is to produce electricity. *

C6 Batteries gradually get weaker as they are used.

C7 The thing we usually call a battery is more accurately called a 'cell'.

C8 A number of cells working together are called a 'battery'.

C9 Electricity from batteries flows in one direction. We call it 'direct' current.

C10 A cell acts as a kind of pump which provides 'pushing power' driving electricity round the circuit. This is called the 'voltage' of the battery.

C11 When cells work in opposition, with positive connected to positive or negative to negative, the actual voltage is the difference between the two separate voltages.

C12 When cells work in conjunction, with positive connected to negative, then the actual voltage is the sum of the two separate voltages.

D	CONDUCTORS AND INSULATORS
D1	Materials which allow electricity to pass through them are called 'conductors' of electricity. *
D2	Metals are usually good conductors of electricity. (Materials A4)
D3	Plastics and rubber are poor conductors of electricity. (Materials A4)
D4	Very poor conductors of electricity are called 'insulators'. *
D5	Water and our bodies conduct electricity well enough for mains electricity to be dangerous. *
D6	The uses we can make of materials depend upon whether they conduct electricity. (Materials E1)
D7	A thicker wire lets more electricity flow than a thinner one.
D8	A shorter wire lets more electricity flow than a longer one.
D9	We can make dimmers which control the flow of electricity in a circuit.
D10	*Materials resist the flow of electricity.*
D11	*Different materials have a different resistance to electricity. Those with a very high resistance do not easily allow electricity to pass and they are insulators. Materials with a low resistance are conductors of electricity.*
D12	*Any material will allow electricity to flow through it if the voltage applied is great enough.*
D13	*The resistance of an object depends upon its length, the material of which it is made, and its thickness. (This idea is considered to be 'extension' in that it is very much harder for pupils to consider the combination of all three factors than for them to consider each one separately.)*
D14	*When an electric current passes through a solution it may decompose the material in solution into new substances.*

E	MAKING DIFFERENT CIRCUITS
E1	When bulbs or other items in a circuit are arranged one after the other in the circuit we say that they are 'in series'.*
E2	If the pathway of a circuit has branches which then join together again then the items in the branches are said to be 'in parallel'. * ●
E3	The order in which cells, switches and bulbs are put in a simple circuit does not affect the way they work.
E4	When several bulbs are included in series and one of them blows or is removed, they all go out.
E5	When several bulbs are included in parallel and one of them blows or is taken out, the others stay alight.
E6	When two or three bulbs are used in series in a circuit they are dimmer than one bulb was with the same cell.
E7	When two or three bulbs are used in parallel in a circuit each is nearly as bright as one bulb was with the same cell.
E8	*When two or three bulbs are used in series in a circuit they are dimmer than one bulb was with the same cell because of the increased resistance of the circuit.*
E9	*When several bulbs are included in series in a circuit and one of them blows or is removed, then they all go out because there is no longer a complete pathway.*
E10	*When several bulbs are included in parallel in a circuit and one of them blows or is removed, then the others stay alight because the pathways through them are still complete.*

F	ELECTRICITY AND MAGNETISM	G	ELECTRICITY FOR LIGHTING AND HEATING
F1	Power stations make use of coal, oil, nuclear fuel or the force of falling water to make electricity. *	G1	When electricity is passing through wires they get hotter.
F2	A magnet moving in a coil of wire and generating electricity is called a 'generator'. *	G2	Some wires can become so hot that they glow and give out light. These are used in light bulbs.
F3	As electricity is being made in a generating station other sources of energy such as coal or oil are used up. *		
F4	Scientists are trying to develop ways of making electricity using wave, tide or wind power so as to save fuels. *		
F5	When a magnet is near a coil of wire and one of them is moved, electricity begins to flow in the wire. This is how we can make electricity. The wire coil or the magnet can be moved by any kind of engine, using for example water or steam power.		
F6	If electricity flows through a wire near a magnet, the wire may move.		
F7	The movement of a coil of wire near a magnet can be used to make motors which are driven by electricity.		
F8	Electricity can be used to make a magnetic material into a magnet. (Magnets and Magnetism B6)		
F9	When electricity flows in a coil of wire wrapped around a soft iron core, the iron becomes magnetised whilst the current is switched on. (Magnets and Magnetism B7)		
		G3	Fuse wires are made of a metal which easily melts, breaking the circuit if too much electricity passes in the wires.
		G4	Those wires which become hot and glow do so because of the material of which they are made and also because of the thinness of the wire.
F10	*We cannot make electrical energy: we simply turn other forms of energy into electrical energy.*	*G5*	*When electricity passes through wires they get hot because the material resists flow.*
F11	*The direction of movement of a magnet in a coil of wire determines the direction in which electricity flows in the wire.*	*G6*	*In a light bulb electrical energy is converted to light energy.*
F12	*The size of current which flows in a coil of wire moving in a magnetic field depends upon the strength of the magnet, the number of turns in the coil and the speed of the movement.*	*G7*	*When a light bulb is working the filament would burn out if air were in the bulb. Bulbs either have a vacuum or inert gases to prevent this.*

H MAINS ELECTRICITY

H1 The electricity we get from the power station is called 'mains' electricity. *

H2 Because the human body can conduct electricity, mains electricity is so dangerous that it can kill you. *

H3 All electrical equipment should always be sent to a qualified electrician for mending. *

H4 We use electricity in homes and in industry to provide heat and light, to drive motors and to make things move; and to make sounds.

H5 The national grid system links all generating stations so that users can draw upon electricity made anywhere in England.

H6 A mains circuit needs to be a complete circuit including the power station.

H7 In a mains circuit the brown wire is the one we call 'live'.

H8 In a mains circuit the blue wire is called the 'neutral' wire.

H9 In a mains circuit the green and yellow striped wire is called the 'earth' wire. This is a safety device.

H10 The switch and the fuse in a mains circuit are always in the brown, live, side of the circuit.

H11 Electricity in mains circuits does not flow in one direction but changes direction back and forth very quickly. We call it 'alternating current'.

H12 When we use electricity in the home we always turn it into another form of energy.

H13 The only way to make electrical energy is to convert other forms of energy into electrical energy.

H14 The electrical force, or voltage, in mains circuits is very much greater than the force in battery operated circuits.

H15 The blue wire of a mains circuit completes the circuit back to the power station.

H16 The earth wire provides a pathway to earth from an appliance so that, if the appliance becomes live, the current will not flow through a person but through the earth wire.

H17 Electricity is the form of energy which is easiest to transmit from one place to another.

J STATIC ELECTRICITY

J1 Static electricity is formed when certain materials are rubbed together.

J2 When our clothes stick to us and crackle when we take them off it is because they have a kind of electricity called 'static electricity'.

J3 It is harder to make static electricity in damp weather.

J4 Lightning is an enormous electric spark.

J5 Static electricity collects in clouds and causes thunder and lightning when it goes to earth.

J6 Tall buildings are fitted with lightning conductors to allow electricity to leak away all the time so that lightning does not happen.

J7 An object which has static electricity attracts tiny bits of dirt, paper or even a stream of water.

J8 Records and tapes build up static electricity which attracts bits of dust to the surface.

J9 We can prevent the build up of static electricity by coating objects with 'antistatic' fluid.

J10 Static electricity gradually leaks away to earth from a charged object, especially quickly in damp air. The charged object gradually returns to normal.

J11 When static electricity has a pathway to travel along it becomes current electricity.

Activities for pupils are listed below, together with references, as suggestions for teachers to consider in preparing an approach to this theme. These activities can be taken together or they can be used individually within other topics as shown in Section 5.2. Most of them will also contribute to core skills and ideas on other maps.

Activity	Reference ○	Skills Used *	Ideas Developing *	Years	*Minimum* Time Needed
Making electricity	Science 5/13, Children and Plastics, page 68	1,2,3,4,6, 7,8,9	J1	1 or 2	½ hour
Setting up a simple circuit with a switch	Explore and Discover, pages 272 - 273, 278 - 279	1,2,3,4,6, 7,8,9,10	A1,A2,A4, A5,A6,A7, B1,E3	3	1 hour
Sorting materials into conductors and insulators	Explore and Discover, pages 274 - 275 Nuffield Combined Science Teachers' Guide I, pages 357 - 362	1,2,3,4,6, 7,9	D1,D2,D3, D4,D6	3	1 hour overlapping with work on materials
Finding out more about circuits	Nuffield Combined Science Teachers' Guide I, pages 314 - 321 and Activities 5, page 3	1,2,3,4,6, 7,8,9	C1,C2,C3, C4	3	2 hours
Finding out whether the position of the bulb in a circuit effects its brightness	Explore and Discover, pages 275 - 277	1,3,4,6,7, 8,9	E1,E2,E4 E5	3	1 hour
Investigating the link between electricity and magnetism	Nuffield Combined Science Teachers' Guide I, pages 323 - 327	1,2,3,4,6, 7,8,9	F6	4	1 hour overlapping with work on magnets
Making a current balance	Nuffield Combined Science Teachers' Guide I, pages 327 - 332	3,4,6,7,8, 9,10	F6	4	1 hour overlapping with work on magnets
Using ammeters to measure current	Nuffield Combined Science Teachers' Guide I, pages 332 - 345	1,2,3,4,6, 7,8,9	A3,B2,B3	4	2 hours
Making batteries	Nuffield Combined Science Teachers' Guide I, pages 370 - 372 Science 5/13, Metals Stages 1 and 2, pages 47 - 48	1,2,3,4,6, 7,8,9,10	C5,C8	4	1 hour
Finding out about electricity passing through our bodies	Nuffield Combined Science Teachers' Guide I, pages 381 - 382	1,2,3,4,6, 8,9	D5,G1,G2, G3	4	1 hour

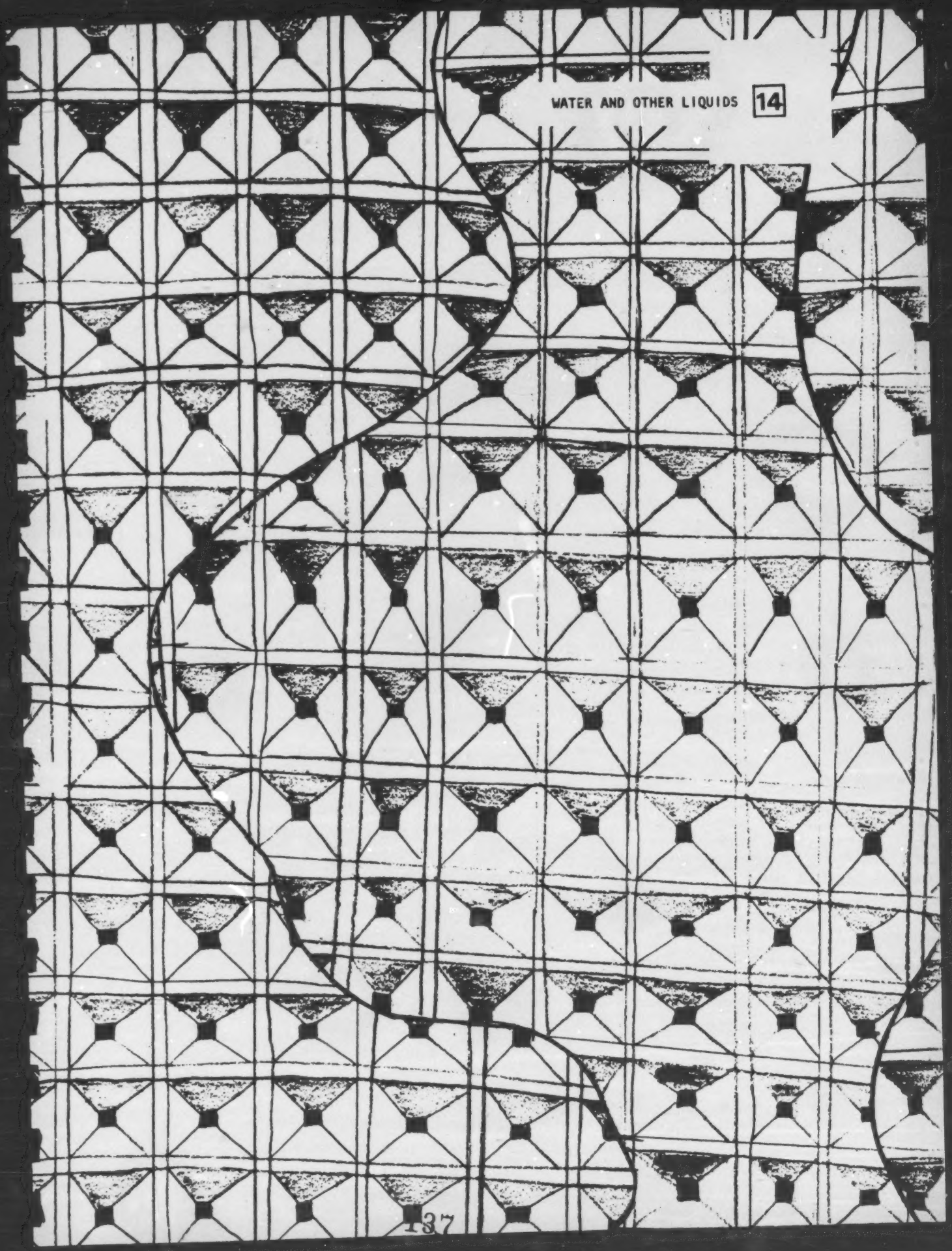
/cont...

Activity	Reference o	Skills Used *	Ideas Developing *	Years	Minimum Time Needed
Investigating the heating effect of electricity	Nuffield Combined Science Teachers' Guide I, pages 321 - 323	1,2,3,4,6, 7,8,9,10	H1,H2	4	2 hours
Thinking about energy	Science for the '70s Pupils' Book 1, pages 32, 66	1,3,4,6,7, 8,10	F1,F3,F4	4	1 hour

o Details of references are given in Appendix 1

* Skills are listed by number with reference to the sequence of investigation techniques at the beginning of this map.

Ideas are listed by section and number with reference to the preceding pages. An activity may simply contribute to the development of an idea or it may be designed specifically to teach a particular idea.


WATER AND OTHER LIQUIDS
14

☐ Pupils develop scientific ideas about water and other liquids by working like scientists on investigations.

☐ A practical science activity for pupils will usually give them the opportunity to work through the sequence of investigation techniques and to begin to develop scientific ideas.

☐ CORE SCIENCE is made up of both the techniques of investigating described below, and the emerging ideas which follow.

CORE SCIENCE STARTS HERE

⇩

PART I - INVESTIGATING

⇩

HAVING IDEAS

1. Making a start

   (a) Asking questions which can be answered by observing or experimenting

   For example, 'Is the water we get from different places all the same?' or 'Do things weigh the same when they are in water as they do in air?'

   or (b) Expressing ideas which can be put to the test

   For example,

   (a) predicting which wet garment will dry first;

   or (b) predicting which materials will float.

2. Planning observations, fair tests or controlled experiments, in small group discussion, individually or in a whole class

   For example,

   (a) planning an experiment to find out what helps a solid to dissolve;

   or (b) planning how to find the best conditions for drying clothes.

⇩

COLLECTING EVIDENCE

3. Making observations, either directly or from experiments, and measuring when it is appropriate

   (a) looking for changes as water is heated to boiling and as it condenses from steam;

   (b) observing the characteristics of water as it pours in streams and droplets;

   (c) observing a variety of organisms living in pond water, using magnifiers or microscopes;

/continued overleaf

COLLECTING EVIDENCE (continued)

(d) observing the differences between water samples from different places, differences in colour or smell for example;

(e) looking for changes in cloud shapes;

(f) measuring water temperatures, particularly as ice melts and as water boils;

(g) handling and measuring volumes of liquids;

(h) measuring rainfall;

(j) separating water from suspensions by filtration and from solutions by evaporation; using evaporating equipment and simple distillation equipment;

(k) using indicator colour changes to sort materials into acids, alkalis and neutral substances;

(l) measuring the weight of objects in air and then in water.

⇩

HANDLING EVIDENCE

4. Recording

(a) recording temperature changes at regular intervals;

(b) making tables, bar-graphs and line-graphs to record observations and measurements, with the teacher's help in selecting scales for graphs.

5. Calculating

(a) calculating temperature changes from a series of temperature readings over a period of time;

(b) calculating changes in volume when a volume of water is added to another or when a solid is immersed in water.

6. Talking in small groups or as a whole class, children will explore and develop their own ideas about their experiences

7. Trying to classify, order and look for patterns

(a) sorting materials and objects into 'floaters' and 'sinkers';

(b) sorting substances into those which are soluble and those which are insoluble;

(c) recognising liquids as a group distinct from solids or gases;

(d) sorting solutions into 'acids', 'alkalis' or 'neutral'.

(The patterns which pupils will see in their observations follow as scientific ideas). →

8. Trying to explain in terms of cause and effect

For example, 'The clothes dried quicker because they were in a warmer place'.

(Explanations of a more sophisticated kind follow as extension ideas). →

9. Describing and presenting evidence and ideas

Children will prepare tables, charts, graphs and bar-graphs; and they will be talking and writing in their own words.

⇩

MAKING USE OF SCIENTIFIC SKILLS AND IDEAS

10. Solving problems and making useful things

For example,

(a) designing a boat for speed;

(b) designing a clothes drier.

PART II - DEVELOPING SCIENTIFIC IDEAS

In getting to know water pupils will begin to develop some ideas about liquids in general. However, their experience of liquids will be very largely limited to water.

	A	WHAT IS WATER LIKE?
CORE ideas are important scientific ideas which the majority of pupils can grasp, by the age of thirteen, in the form in which they are expressed here. They try to show the point reached by the majority of 13-year-olds on their journey towards understanding more formal scientific ideas. Most of the core ideas are patterns which pupils will see in their own practical activities, but there are some which cannot be presented practically and which therefore need verbal or audio-visual teaching; these are indicated by *. ● indicates ideas which pupils have difficulty in grasping but which are so important that they are attempted in the middle years.	A1	Materials can be sorted into three sets: solids which have a definite shape; liquids which take the shape of their container and gases which spread into all the available space. (Materials A1) (Air and Other Gases A1)
	A2	Water can exist as liquid water, solid ice or as steam depending upon its temperature. (Heat G1)
	A3	Samples of water from different* places are not quite the same. They have small amounts of different substances dissolved in them. * ●
SUPPLEMENTARY ideas are no more difficult than core ideas, but they are less important.	A4	Droplets of water have rounded surfaces.
	A5	When detergent is added to water drops their surfaces become flatter.
	A6	Water turns blue cobalt chloride paper pink.
	A7	1 cm^3 water has a mass of 1 gm.
EXTENSION ideas are more difficult, abstract ideas which may be understood by pupils who have reached a later stage of conceptual development, characterised by abstract thinking.	*A8*	*Most liquids contract when they turn into solids but water expands and becomes less dense as it freezes.*
	A9	*There is a force in liquid surfaces which causes droplets to have round surfaces.*
	A10	*Water is a combination of hydrogen and oxygen.*
	A11	*Electricity breaks up water into hydrogen and oxygen.*
	A12	*There is a pressure within water. The pressure is greater lower down in a volume of water.*

B	WATER AND LIVING THINGS	C	OTHER LIQUIDS
B1	All animals and plants need water as well as food to stay alive, even if they live on land. (Food and Feeding B1)	C1	Most of the liquids we meet are made up of water with other materials dissolved in it.
B2	Water contains dissolved air which is used by the animals and plants living in water. * ● (Air and Other Gases D4)	C2	Some liquids are materials which do not have water in them. This applies to oil, methylated spirits and mercury for example. ●
B3	All living things and many materials contain water. *		
B4	Some living things, like water melons and jelly fish, are made up mainly of water.	C3	Some liquids will not mix with water and they float on top. Oil is an example of such a liquid.
B5	Plants and animals which live in water are supported by the water.	C4	Coloured inks are mixtures of different coloured liquids.
B6	Plants get water from the ground through their roots and they lose water through their leaves.	C5	A mixture of coloured liquids, like ink, is separated when the mixture spreads on filter paper.
B7	Some animals and plants need to live in water: they cannot live in air.		
B8	Most animals which live in water are streamlined for moving through it.		
B9	*Water vapour comes out of the pores in a leaf. This helps the flow of water through the plant and also keeps the plant cool.*	*C6*	*Sometimes a material which looks like one liquid is in fact several liquids mixed together.*
B10	*The weight of large animals and plants which live in water is supported by the water.*	*C7*	*Every liquid has its own freezing temperature and boiling temperature. These temperatures are helpful in identifying liquids.*

D	HEATING AND COOLING WATER	E	WATER SUPPLY
D1	Ice melts to form water when it is heated and freezes to form ice when it is cooled. (Heat B2 and D5)		(Many of these ideas may arise in the Humanities area of the curriculum).
D2	When water boils it forms steam and when steam is cooled it condenses to form liquid water. (Heat C3, D1 and G1)	E1	Rain water can be collected and stored in reservoirs.
D3	Water has its own freezing temperature (0°C) and its own boiling temperature (100°C). (Heat E3 and E4)	E2	We use many litres of water every day in our homes, and industries use a very large amount of water for washing and cooling processes.
D4	Although cooling usually causes contraction, freezing water expands with such force that it can break its container. (Heat D3)	E3	Water supplies have solid materials dissolved in the water.
D5	When water is heated the hot water rises to the top and cooler water falls to the bottom. (Heat D6)	E4	Water is made safe for drinking by treatment at the waterworks. It is filtered and germs are killed. *
D6	Water expands when it is heated and contracts when it is cooled. (Heat D2)	E5	Water supplies and rivers are sometimes contaminated by harmful materials from farms and factories. We call this 'water pollution'.
D7	When water is boiling its temperature does not rise even though heating is continued. (Heat D4)		
D8	If you dissolve a substance in water the freezing point and the boiling point of the water are changed.	E6	Rain water runs over the ground where the rock does not soak it up.
D9	Water pipes and even rocks can be cracked by the force of freezing water.		
D10	There are currents in the oceans. These are streams of water at a different temperature from the rest of the ocean.		
D11	When water cools, like other liquids, in contracts, but water is unusual in that it expands as it is cooled from 4°C to 0°C.		
D12	The hot water system of a house makes use of hot water rising and cold water falling back down to the heater.		
D13	*Only pure water, having nothing dissolved in it, will boil at 100°C.*	*E7*	*The solids dissolved in water are from the rocks with which the water has come into contact.*
D14	*The boiling temperature of water is affected by the pressure of the atmosphere. Where the pressure is lower, like at the top of a mountain, water boils a lower temperature than it does at sea-level.*		
D15	*Water boils when all the particles within it vibrate so vigorously that they escape from one another and become a gas.*		

F	WATER VAPOUR IN THE AIR	G	DRYING
F1	There is some water in the air even though we cannot see it. (Air and Other Gases G1)	G1	Even at low temperatures water is changing into a vapour in the air. This is called 'evaporation'. * ●
F2	We call the water in the air 'water vapour'. * (Air and Other Gases G2)	G2	Water evaporates more quickly if it is heated and if a draught blows over the surface.
F3	Water vapour is an invisible gas. * ● (Air and Other Gases G3)		
F4	Our breath contains a lot of water vapour. (Air and Other Gases G4)		
F5	When water dries up it turns into water vapour in the air. (Air and Other Gases G4)		
F6	When water boils it becomes water vapour.		
F7	The water vapour from boiling water is called 'steam'. But we also use the word 'steam' for the cloud of tiny droplets of water formed when steam condenses. *		
F8	Because water is always evaporating from the surface of the earth and water is always falling from clouds, we have a cycle of rising and falling water in the atmosphere around the earth. ●		
F9	Mist and fog are water droplets suspended in the air.	G3	Clothes dry best on warm dry windy days.
F10	When we breathe onto a cold surface water vapour in our breath forms water droplets on the surface.	G4	When clothes dry water evaporates from them.
F11	The amount of water vapour in the air varies from day to day and place to place.	G5	Spilt water and rain puddles dry by evaporation.
F12	Clouds and the mist we can see from the kettle are not gases. They are made up of tiny water drops.	G6	Most animals lose water by evaporation from their skins.
F13	*The amount of water vapour in the air can be measured. It is called the 'humidity' of the air.*	*G7*	*Water evaporates from leaves.*
F14	*There is a limit to how much water vapour air can hold at any temperature.*	*G8*	*When water evaporates particles escape from its surface to become a gas.*
F15	*Warm air can hold more water vapour than cold air.*	*G9*	*Losing water from skin by evaporation helps an animal to keep cool.*
F16	*When air holds as much water vapour as it can, we say it is 'saturated'.*	*G10*	*Materials which absorb a lot of water take longer to dry than those which are not very absorbent.*
F17	*Air is not normally saturated with water vapour.*	*G11*	*When clothes dry and spilt water evaporates the water becomes water vapour in the air.*
F18	*Steam only exists at temperatures above the boiling point of water (100°C). It turns back into water if the temperature falls below 100°C.*	*G12*	*A material which is very absorbent will take longer to dry than one which is not.*
F19	*Water vapour condenses when it is cooled enough, to form water droplets.*		
F20	*More of the earth's surface is covered by water than by land. There is a very large surface for evaporation of water from the sea.*		

H WATER DISSOLVING MATERIALS

(Children's experience of dissolving will be limited mainly to cases of solids dissolving in water).

H1 Some solids dissolve in water and others do not. (Materials C3)

H2 When a solid has dissolved in water you cannot see the solid and the water looks clear. When you dissolve a coloured solid you can see the colour although the solid is not visible.

H3 A solid dissolved in a liquid is called a 'solution'. *

H4 If water with solids dissolved in it is heated or left to dry up, the water evaporates leaving the solids behind.

H5 Most solids dissolve more quickly in hotter water.

H6 Small pieces of a solid dissolve more quickly than larger pieces.

H7 Stirring helps solids to dissolve more quickly.

H8 Those materials which do not dissolve can be strained or filtered off.

H9 A solid which has dissolved in a liquid cannot be recovered by filtering or straining.

H10 If you want to dissolve a solid which will not dissolve in water you may be able to find another liquid that will dissolve it.

H11 A liquid which dissolves another material is called a 'solvent'.

H12 A solid which dissolves in a liquid is called a 'solute'.

H13 A solvent with its solute dissolved forms a solution.

H14 When a solid dissolves we say it is 'soluble'.

H15 A liquid eventually becomes full of a dissolved solid and will not dissolve any more. We say then that it is 'saturated'.

H16 Water which has a lot of material from rocks dissolved in it is called 'hard' water.

H17 Hard water needs more soap than soft water before it gives a lather.

H18 Some of the solids which are left after a solution is evaporated are in crystal shapes. The crystals formed are bigger when a solution evaporates more slowly.

H19 The crystals of different materials are different shapes.

H20 Gases, as well as solids, are dissolved in most samples of water.

J ACIDS AND ALKALIS

(Most pupils are not likely to understand the terms 'acid' and 'alkali' except as labels, nor to understand the relationship between acids and alkalis).

J1 The liquids we call 'acids' and 'alkalis' give different colours with indicator solutions.

J2 Many acids and alkalis are dangerous. They will destroy clothes and skin! *

J3 Liquids which are neither acidic nor alkaline are called 'neutral'.

J4 Acids and alkalis react together to make a new substance which is neither acidic nor alkaline.

J5 When an acid and an alkali react together we say one 'neutralizes' the other.

K FLOATING OR SINKING IN WATER

K1 Material blocks can be sorted into two sets: those which float and those which sink in water. (Materials C1)

K2 When boats are laden they float lower in the water.

K3 A small piece of a sinking material can rest upon the surface of water. (Materials C2)

K4 A material which sinks can be made to float by altering its shape. (Materials C6)

K5 Some of the things which sink in water will float in salt water.

K6 Objects weigh less in water. An object which is floating does not show any weight on a spring balance.

K7 Ice floats on water.

K8 Oil floats on water.

K9 A material sinks in water if it is more dense than water; materials which float on water are less dense than water.

K10 Ice floats on a pond because it is less dense than water.

K11 An object floats on water when the upward push of the water on it is as great as the weight of the object. That is why it has no weight when it is floating.

K12 A small piece of a sinking material rests on the surface of water because it is held up by forces in the surface of the water.

L MATERIALS ABSORBING WATER

('Materials' include all substances and not simply fabrics).

L1 Some materials absorb water and others are waterproof.
(Materials C3)

L2 Water rises in materials like fabrics, wood, bricks and rocks which have tiny air spaces.
(Materials C4)

L3 Materials which soak up water are called 'absorbent' materials.

L4 Of those materials which absorb water, some absorb more water than others.

L5 Materials can be treated to make them 'waterproof'.

L6 Water which has detergent added is more easily soaked up by materials.

Activities for pupils are listed below, together with references, as suggestions for teachers to consider in preparing an approach to this theme. These activities can be taken together or they can be used individually within other topics as shown in Section 5.2. Most of them will also contribute to core skills and ideas on other maps.

Activity	Reference ○	Skills Used *	Ideas Developing *	Year	*Minimum* Time Needed
Looking at water drops	Science 5/13, Holes, Gaps and Cavities, pages 26 - 37 Science 5/13, Early Experiences, page 89	3,4,6,7,8, 9	-	1 or 2	1 hour
Looking at water on different surfaces	Science 5/13, Early Experiences, pages 89 - 90 Science 5/13, Using the Environment 1 Early Explorations, page 18 Nuffield Combined Science Teachers' Guide II, pages 12 - 14 and Activities 6, pages 15, 18 - 19	1,2,3,4,6, 7,8,9	L1	1 or 2	1 hour overlapping with work on materials
Measuring rainfall	Science 5/13, Early Experiences, page 89	3,4,6,7	F8	1 or 2	½ hour plus recording at inverals
Investigating wetting and drying	Science 5/13, Early Experiences, pages 84 - 88 Science 5/13, Using the Environment 1 Early Explorations, page 17 Science 5/13, Change Stages 1 and 2, page 48 Teaching Primary Science Fibres and Fabrics, pages 16 - 18 Science in a Topic, Clothes and Costume page 28 and Houses and Homes, page 26	1,2,3,4,5, 6,7,8,9,10	F5,G1,G2, L1,L2	1 or 2	1 hour plus observations at inverals, overlapping with work on materials
Sorting materials into floaters and sinkers and investigating change changes in weight.	Science 5/13, Early Experiences, page 45 Science 5/13, Like and Unlike, pages 12 - 13 Nuffield Combined Science Teachers' Guide II, pages 16 - 18 and Activities 6 pages 23 - 24	1,2,3,4,5, 6,7,8,9	K1,K2,K3	2	1 hour overlapping with work on materials

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Activity	Reference	Skills Used *	Ideas Developing *	Year	Minimum Time Needed
Adding substances to water	Science 5/13, Change Stages 1 and 2, page 56 Nuffield Combined Science Teachers' Guide II, pages 8 - 11 and Activities 6, pages 13 - 14 Explore and Discover, pages 74 - 76	1,2,3,4,5, 6,7,8,9	H1,H2,H3, H4,H5,H6, H7,H8,H9	3	2 hours overlapping with work on materials
Trying to make rock salt purer	Nuffield Combined Science Teachers' Guide I, pages 78 - 83	1,2,3,4,6, 7,8,9,10	H1,H2,H3, H4,H5,H6, H7,H8,H9	3	1 hour
Watching what happens when water is heated	Nuffield Combined Science Teachers' Guide II, pages 19 - 21	3,4,6,7,8, 9	A2,B2,D2, D3,D5,D7, F6	3	1 hour overlapping with work on heat
Finding out about water freezing	Science 5/13, Change Stages 1 and 2, pages 49 - 51 Nuffield Combined Science Teachers' Guide II, pages 21 - 22 Explore and Discover, pages 71 - 73	1,3,4,6,7, 8,9	A2,D1,D3, D4	3	½ hour overlapping with work on heat
Melting ice and boiling water	Nuffield Combined Science Teachers' Guide I, pages 170 - 171 Explore and Discover, pages 70 - 71	1,3,4,6,7, 8,9	A2,D1,D2, D3,D5,D7, F1	3	2½ hours overlapping with work on heat
Looking at water animals	Nuffield Combined Science Teachers' Guide II, pages 5 - 7 and Activities 6, pages 10 - 12 Science 5/13, Minibeasts, pages 12, 45 - 46, 72 - 75	3,4,6,7,8, 9	B2	3	1 hour
Looking at water from different places	Science 5/13, Using the Environment 1 Early Explorations, page 11 Nuffield Combined Science Teachers' Guide II, pages 4 - 5	2,3,4,6,7, 8,9	A3	3	1 hour
Investigating the effect of shape on floating and sinking	Nuffield Combined Science Teachers' Guide II, pages 18 - 19 and Activities 6, pages 25 - 27	1,2,3,4,6, 7,8,9,10	K3,K4	4	1 hour

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Activity	Reference o	Skills Used *	Ideas Developing *	Year	Minimum Time Needed
Using coloured substances from plants	Nuffield Combined Science Teachers' Guide I, pages 103 - 106 Science in a Topic, Food, pages 40 - 41	3,4,6,7,8, 9,10	J1,J3	4	1 hour
Looking for water in air and in other materials	Nuffield Combined Science Teachers' Guide I, pages 240 - 243 (Activity 12, 16 and 17) and Activities 4, pages 9, 11 Nuffield Combined Science Teachers' Guide I, pages 90 - 97 and Activities 1, pages 67 - 68	3,4,5,6,7, 8,9	B3,C1,C2, F1,F2,F3, F4	4	2 hours

o Details of references are given in Appendix 1

* Skills are listed by number with reference to the sequence of investigation techniques at the beginning of this map.

Ideas are listed by section and number with reference to the preceding pages. An activity may simply contribute to the development of an idea or it may be designed specifically to teach a particular idea.

☐ Pupils develop scientific ideas about air and other gases by working like scientists on practical investigations.

☐ A practical science activity for pupils will usually give them the opportunity to work through the sequence of investigation techniques and to begin to develop scientific ideas.

☐ CORE SCIENCE is made up of both the techniques of investigating described below, and the emerging ideas which follow.

CORE SCIENCE STARTS HERE

⇩

PART I - INVESTIGATING

⇩

HAVING IDEAS

1. Making a start

   (a) Asking questions which can be answered by observing or experimenting

   For example, 'Is there any difference between the air we breathe in and that we breathe out?' or 'How much does air weigh?'.

   or (b) Expressing ideas which can be put to the test

   For example, 'A candle under a bigger jar will burn for a longer time'.

2. Planning observations, fair tests or controlled experiments, in small group discussion, individually or in a whole class

   For example, planning tests to find out whether a hole in a parachute makes it work better.

⇩

COLLECTING EVIDENCE

3. Making observations, either directly or from experiments, and measuring when it is appropriate

   (a) observing the feel and the effects of moving air;

   (b) using plastic syringes to feel the springiness of air;

   (c) observing and measuring the changes in a volume of air when a candle is burnt in it;

   (d) measuring the time taken for candle flames to die out in limited air supplies;

   (e) measuring air temperatures.

HANDLING EVIDENCE

4. Recording

   Making tables and bar-graphs to record measurements and observations.

5. Calculating

   (a) trying to calculate the fraction of oxygen and nitrogen in air from the measured volume of oxygen in a known volume of air;

   (b) calculating the weight of a volume of air from 'before' and 'after' weights of a container to which air has been added.

6. Talking in small groups or as a whole class, children will explore and develop their own ideas about their experiences.

7. Trying to classify, order and look for patterns

   Recognising gases as a group distinct from solids and liquids.

   (The patterns which pupils will see in their observations follow as scientific ideas). →

8. Trying to explain in terms of cause and effect

   For example, 'Air in the flask is preventing water from getting in'.

   (Explanations of a more sophisticated kind follow as extension ideas). →

9. Describing and presenting evidence and ideas

   Children will prepare drawings, tables and bar-graphs and they will be talking and writing in their own words.

⇩

MAKING USE OF SCIENTIFIC SKILLS AND IDEAS

10. Solving problems and making useful things

    For example,

    (a) keeping a room warm and ventilated;

    (b) designing an anemometer to measure wind speed;

    (c) designing an oxygenator for a fish tank;

    (d) designing a fire-extinguisher.

PART II - DEVELOPING SCIENTIFIC IDEAS

	A GASES
CORE ideas are important scientific ideas which the majority of pupils can grasp, by the age of thirteen, in the form in which they are expressed here. They try to show the point reached by the majority of 13-year-olds on their journey towards understanding more formal scientific ideas. Most of the core ideas are patterns which pupils will see in their own practical activities, but there are some which cannot be presented practically and which therefore need verbal or audio-visual teaching; these are indicated by *. ● indicates ideas which pupils have difficulty in grasping but which are so important that they are attempted in the middle years.	A1 Materials can be sorted into three sets: solids which have a definite shape; liquids which take the shape of their container and gases which spread into all the space available. (Materials A1) (Water and Other Liquids A1) A2 Most gases are colourless. A3 The most common gases are oxygen and nitrogen. * A4 Natural gas, which we use for cooking, is a mixture of methane and other flammable gases. *
SUPPLEMENTARY ideas are no more difficult than core ideas, but they are less important.	
EXTENSION ideas are more difficult, abstract ideas which may be understood by pupils who have reached a later stage of conceptual development, characterised by abstract thinking.	

B AIR

B1 Air is all around us.

B2 Although you cannot see air you can feel it, as wind, when it moves.

B3 We make use of the force of moving air in many ways.

B4 Air has weight. ●

B5 Air is an elastic material: it can be stretched and compressed.

B6 Air expands when it is heated and contracts when it is cooled. (Heat C1)

B7 The air around the earth is pressing in all directions. We call this 'air pressure'.●

B8 We can measure the pressure of gases using a manometer.

B9 Hot air rises and cold air falls.● (Heat C2)

B10 Air is a mixture of different gases. It is made up of approximately 1/5th oxygen, approximately 4/5ths nitrogen, and small amounts of other gases including carbon-dioxide and water vapour.●

B11 When harmful substances are added to the air from cars or chimneys, the air becomes polluted.

B12 Trees are important not only for wood and for their beauty, but because they are mainly responsible for replenishing the oxygen of the air and removing carbon-dioxide. They are the world's main air conditioners. * ●

B13 Hovercraft, yachts, windmills, aeroplanes and kites all make use of the force of moving air for their movement.

B14 We can use an anemometer to measure wind speed.

B15 We can use a barometer to measure air pressure.

B16 Slight changes in air pressure over the surface of the earth affect weather.

B17 Heat from plants, animals, factories and homes affects the air temperature in an area.

B18 Because hot air rises and cool air falls, heating air causes a cycle of rising and falling air. This is called a 'convection current'.

B19 Air pressure is lower at high altitudes than it is at sea level.

B20 In addition to oxygen, nitrogen, carbon-dioxide and water vapour in the air there are very small amounts of five other gases. They are called the 'noble' gases.

B21 The air around the earth's surface is constantly moving: it is compressed in some places and thinned out in others.

B22 Air moves from a place where it is compressed to one where it is thinned out. This is the cause of winds.

B23 When warm air rises surrounding air rushes to take its place, and the rushing air is felt as a wind.

B24 If air is in a sealed container its pressure rises if it is heated and falls if it cools.

B25 The pressure in a gas is caused by the movement of its particles.

C CARBON-DIOXIDE

C1 Carbon-dioxide is a heavy gas. ●

C2 Carbon-dioxide does not usually allow things to burn in it.

C3 Carbon-dioxide gas will put out many materials which are burning.

C4 Because it does not allow burning and because it is a heavy gas which forms a blanket, carbon-dioxide is used in many fire-extinguishers. *

C5 We can detect carbon-dioxide because it makes clear limewater go milky when the gas is bubbled through.

C6 Carbon-dioxide is used in fire extinguishers; it is the gas which makes bread and cakes rise, and it is the gas in fizzy drinks.

C7 Solid carbon-dioxide is called 'dry ice'.

C8 When dry ice is warmed it does not form liquid carbon-dioxide. It changes from a solid straight to carbon-dioxide gas.

C9 We can make carbon-dioxide in the laboratory.

C10 Carbon-dioxide is made when yeast cells grow.

C11 Plants use carbon-dioxide from the air in making their own food materials.

D OXYGEN

D1 Oxygen is needed by animals.

D2 Oxygen is needed by plants. ●

D3 The air we breathe out contains more carbon-dioxide and water vapour and less oxygen than the air we breathe in.

D4 Oxygen dissolves in water. (Water and Other Liquids B2)

D5 Living things which live in water use dissolved oxygen from the water. * (Water and Other Liquids B2)

D6 Some materials burn when they are heated in air. (Heat A3)

D7 Materials which are burning need oxygen, from the air, to burn in. If a material is given different volumes of air to burn in, it can burn longer with more air. (Heat A6)

D8 Materials burn more fiercely in oxygen alone than they do in air. You can detect oxygen because it will support burning.

D9 When materials burn they are changed and new materials are formed. ● (Heat A2) (Materials D1)

D10 When metals are left in the open air many of them develop a dull coating. We say that they 'tarnish' and that iron 'rusts'. (Materials A2)

D11 We can make oxygen in the laboratory.

D12 Materials which burn in air combine with the oxygen of the air to form new materials called 'oxides'.

D13 Plants make oxygen when they produce their own food materials.

D14 We use oxygen to make use of the food we eat and to release its energy.

D15 Plants use oxygen and produce carbon-dioxide just as animals do but in sunlight plants make their own food using carbon-dioxide and water and releasing oxygen to the atmosphere as a by-product. The net result of the activities of plants is that oxygen is made available to animals and the carbon-dioxide produced by animals is removed. The trees of the world are mainly responsible for maintaining an atmosphere favourable for animal life.

E NITROGEN	F HYDROGEN
E1 Nitrogen is the inactive part of air which is not used up in burning.	(It is helpful to separate any work which children do on hydrogen from work on air since this helps to emphasise that hydrogen is not a constituent of air).
	F1 Hydrogen is a gas which is not present in air. F2 We can make hydrogen in the laboratory. F3 Hydrogen is the lightest gas. F4 Hydrogen burns in air to produce water. F5 We can detect hydrogen because it produces a 'pop' if you put a lighted splint into a test-tube of it when some oxygen is present.

G	WATER VAPOUR	
G1	There is some water in the air even though we cannot see it. (Water and Other Liquids F1)	
C2	We call the water in the air 'water vapour'. * (Water and Other Liquids F2)	
C3	Water vapour is an invisible gas. *● (Water and Other Liquids F3)	
C4	When water dries up it turns to water vapour in the air and our breath contains a lot of water vapour. (Water and Other Liquids F4 and F5)	

Activities for pupils are listed below, together with references, as suggestions for teachers to consider in preparing an approach to this theme. These activities can be taken together or they can be used individually within other topics as shown in Section 5.2. Most of them will also contribute to core skills and ideas on other maps.

Activity	Reference ○	Skills Used *	Ideas Developing *	Year	*Minimum* Time Needed
Making a wind strength indicator	Science 5/13, Change, page 16 Science 5/13, Early Experiences, page 16	1,2,3,4,6, 8,9,10	B2	1 or 2	1 hour
Investigating parachutes	Science 5/13, Early Experiences, page 24 Science 5/13, Holes, Gaps and Cavities, page 16 Nuffield Combined Science Activities 4, page 12	1,2,3,4,6, 7,8,9,10	B1	1 or 2	1 hour
Making sailing boats	Science 5/13, Early Experiences, pages 22 - 23	1,2,3,4,6, 8,9,10	B1,B2,B3	1 or 2	1 hour
Drying clothes	Science 5/13, Change, page 48	1,2,3,4,5, 6,7,8,9,10	G1,G2,G3, G4	1 or 2	1 hour to set up plus 1 hour recording and developing
Looking at some of the effects of air	Nuffield Combined Science Teachers' Guide I, pages 240 - 243 (Activity 1,2,9,11,17,18 only) Activities 4, pages 4 - 13	1,3,4,6,8, 9	B1,B5,G1, G2	2	1 hour
Watching what happens when water is heated	Nuffield Combined Science Teachers' Guide II, pages 19 - 21	3,4,6,8,9	G1,G2,G3, G4	3	1 hour overlapping with work on heat and water
Looking at some of the effects of air	Nuffield Combined Science Teachers' Guide I, pages 240 - 243 (Activity 1,2,3,4,9,10,11, 13,14)	1,3,4,6,8, 9	B1,B2,B5, B7,B9,B10, G1	3	3 hours
Burning candles	Nuffield Combined Science Teachers' Guide I, pages 240 - 243 (Activity 4,6,7)	1,2,3,4,5, 6,7,8,9,10	B10,D6, D7,E1	3	2 hours
Heating air	Nuffield Combined Science Teachers' Guide I, pages 240 - 243 (Activity 14 and 15) and Activities 4, pages 10 - 11	1,2,3,4,6, 7,8,9	B6,B9	3	1 hour

/cont...

Activity	Reference o	Skills Used *	Ideas Developing *	Year	Minimum Time Needed
Weighing air	Nuffield Combined Science Teachers' Guide I, pages 252 - 253	1,2,3,4,5, 6,8,9	B4	4	1 hour
Investigating air pressure	Nuffield Combined Science Teachers' Guide I, pages 280 - 308 (Experiments: 4a,4b,4c,4d, 4e,4f,4i,4j,4l,4n)	1,2,3,4,5, 6,7,8,9	B7,B8	4	5 hours
Finding out about oxygen and nitrogen	Nuffield Combined Science Teachers' Guide I, pages 263 - 270 and Activities 4, pages 23 - 24	3,4,6,7,8, 9	A2,A3,D6, D8,D9,E1	4	2 hours
Finding out how much of the air is oxygen	Nuffield Combined Science Teachers' Guide I, pages 259 - 263 and Activities 4, pages 18 - 19	1,2,3,4,5, 6,7,8,9	B10,E1	4	1 hour
Looking at the air we breathe out	Nuffield Combined Science Teachers' Guide I, pages 240 - 243 (Activity 12) and Activities 4, page 9 Science for the '70s Teachers' Guide I, page 158	3,4,6,8,9	D3,G4	4	½ hour
Making and using carbon dioxide	Explore and Discover, pages 101 - 102 Nuffield Combined Science Teachers' Guide I, pages 96 - 98	3,4,6,7,8, 9	C1,C2,C3,	4	1½ hours
Finding out about rusting	Nuffield Combined Science Teachers' Guide I, pages 244 - 245	1,2,3,4,6, 7,8,9,10	D10	4	1½ hours

o Details of references are given in Appendix 1

* Skills are listed by number with reference to the sequence of investigation techniques at the beginning of this map.

Ideas are listed by section and number with reference to the preceding pages. An activity may simply contribute to the development of an idea or it may be designed specifically to teach a particular idea.

☐ Pupils develop scientific ideas about materials by working like scientists on practical investigations.

☐ A practical science activity for pupils will usually give them the opportunity to work through the sequence of investigation techniques and to begin to develop scientific ideas.

☐ CORE SCIENCE is made up of both the techniques of investigating described below, and the emerging ideas which follow.

CORE SCIENCE STARTS HERE

⇩

PART I - INVESTIGATING

⇩

HAVING IDEAS

1. Making a start

   (a) Asking questions which can be answered by observing or experimenting

   For example, 'How much weight will a plastic carrier hold?' or 'Are some carriers stronger than others?'

   or (b) Expressing ideas which can be put to the test

   For example, 'Thicker clothes keep us warmer' or 'Several thin layers are warmer than one thick one'.

2. Planning observations, fair tests or controlled experiments, in small group discussion, individually or in a whole class

   For example,

   (a) planning a fair comparison of the amount of water held by different fabrics:

   or (b) planning a fair test of plastic carrier bags.

⇩

COLLECTING EVIDENCE

3. Making observations, either directly or from experiments, and measuring when it is appropriate

   Using measuring equipment when it is needed and designing their own test-rigs whenever possible, pupils will be handling and using a wide variety of materials (metals, plastics, fabrics, wood, leather, paper, building materials), asking:

   (a) is the material hard or soft?;

   (b) is it bendy or rigid?;

   (c) is it stretchy?;

   (d) will it conduct heat?;

   (e) will it conduct electricity?;

   (f) does it float or sink in water?;

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COLLECTING EVIDENCE (continued)

(g) does it float or sink in water?;

(h) what does it look and feel like?;

(j) is it heavy or light for its size?;

(k) what sound does it make when we hit it?;

(l) what changes happen when we heat it?;

(m) can we see through it?;

(n) how easily does it break?.

HANDLING EVIDENCE

4. Recording

   Making tables, charts, bar-graphs and line-graphs to record observations and measurements.

5. Calculating

   (a) temperature changes;

   (b) changes in mass after heating or wetting or in floating;

   (c) changes in length.

6. Talking in small groups or as a whole class, children will explore and develop their own ideas about their experiences.

7. Trying to classify, order and look for patterns

   (a) looking for similarities and differences in feel and appearance so as to sort materials into sets;

   (b) looking for similarities and differences in behaviour with loading, with water, with heat so as to sort materials into sets.

   (The patterns which pupils will see in their observations follow as 'scientific ideas').

8. Trying to explain in terms of cause and effect

   For example, 'The thread broke because the load was too big for it'.

   (Explanations of a more sophisticated kind follow as extension ideas).

9. Describing and presenting evidence and ideas

   Children will prepare tables, charts, bar-graphs and line-graphs and they will be talking and writing in their own words.

MAKING USE OF SCIENTIFIC SKILLS AND IDEAS

10. Solving problems and making useful things

    For example,

    (a) choosing the best material for a model aeroplane;

    (b) designing and testing boats;

    (c) designing and using hardness - testing rigs.

PART II - DEVELOPING SCIENTIFIC IDEAS

Children will have the opportunity to handle a wide variety of materials, often in tasks which are designed for other purposes rather than to focus upon materials. They will gain experience of what materials look and feel like and of how they behave. In this way they will begin to develop the scientific ideas, about metals, plastics, wood, fabrics and other materials, which make up Sections A, C and D.

This is an area of science giving great scope for emphasis on the processes of investigation.

CORE ideas are important scientific ideas which the majority of pupils can grasp, by the age of thirteen, in the form in which they are expressed here.

They try to show the point reached by the majority of 13-year-olds on their journey towards understanding more formal scientific ideas.

Most of the core ideas are patterns which pupils will see in their own practical activities, but there are some which cannot be presented practically and which therefore need verbal or audio-visual teaching; these are indicated by *.

● indicates ideas which pupils have difficulty in grasping but which are so important that they are attempted in the middle years.

SUPPLEMENTARY ideas are no more difficult than core ideas, but they are less important.

EXTENSION ideas are more difficult, abstract ideas which may be understood by pupils who have reached a later stage of conceptual development, characterised by abstract thinking.

A WHAT ARE MATERIALS LIKE?

A1 Materials can be sorted into three sets: solids which have a definite shape, liquids which take the shape of their container, and gases which spread into all the space available. (Air and Other Gases A1) (Water and Other Liquids A1)

A2 When metals are left in the open air many of them develop a dull coating. We say that they 'tarnish', and that iron 'rusts'. (Air and Other Gases D10)

A3 Metals feel cold to the touch; most other materials do not. (Heat F5)

A4 Metals are good conductors of electricity, and most other materials are not. (Electricity D2 and D3)

A5 Iron and some kinds of steel are the magnetic materials we are most likely to meet. (Magnets and Magnetism A2)

A6 Some objects are much more bouyy than others and this depends upon the material used as well as upon the shape of the object.

A7 Plastics can be coloured while they are being made and they are often brightly coloured all through. *

A8 Some plastics are transparent.

A9 Air cannot get through plastic sheet or film and therefore it is dangerous because you cannot breathe through it. *

A10 There are as many kinds of wood as there are types of tree, but all wood has a pattern or 'grain' in it.

A11 A thread is usually made up of many fibres twisted together and most fabrics are made from threads which have been knitted or woven together.

A12 Some materials are heavier than others, for their size.

A13 Some metals are harder than others. The harder ones scratch the softer ones.

A14 Lead is a particularly heavy metal and it is soft.

A15 Aluminium is a particularly light metal.

A16 Mercury is a heavy liquid metal.

A17 Gold is the heaviest metal you are likely to meet. It does not tarnish.

A18 Polythene, polystyrene, P.V.C., nylon and polyester are all examples of plastic materials. It is not always easy to tell which is which.

A19 Polystyrene can be made, as expanded polystyrene, with air trapped in it. This is a very light material.

A20 Some plastics soften when they are heated, others do not.

A21 Threads may be smooth and continuous like fishing-lines or they may be hairy threads made by spinning short fibres together.

A22 Man-made fibres are usually very much stronger than natural fibres of the same thickness.

A23 Fabrics made from stronger fibres will usually be harder wearing.

A24 Nylon and polyester are particularly strong fibres.

A25 Wetting a fibre or a fabric may change its strength.

A26 All materials are made up of tiny particles which are far too small to see.

A27 There are about 100 different chemical elements from which other materials are made.

A28 The particles of which a chemical element is made are called 'atoms'.

A29 The atoms of an element are all alike, and they are different from the atoms of any other element.

A30 Some metals are more ready to react with other materials than other metals are.

A31 When a metal becomes tarnished it is usually because the metal has combined with oxygen from the air. When a metal combines with oxygen the new material is called an 'oxide'.

A32 The strength of a fabric depends upon the fibre from which it is made and also upon its construction.

B WHERE DO MATERIALS COME FROM?

B1 Materials we use come from the earth, from animals and plants that lived and died a long time ago, from animals and plants living now. *
(Rocks and Minerals E1, E2 and E3)

B2 Many materials are made by man from raw materials found on the earth. *

B3 A rock from which a metal is extracted is called an 'ore'. Metals are usually found in the form of ores in the ground. *
(Rocks and Minerals E2)

B4 Gold is found in the ground, not as an ore but as a metal. *

B5 Plastics are not found naturally in the earth; they are man-made. *

B6 Wood is made by living trees and the grain of the wood is caused by the annual rings formed in the trunk as the tree grows.

B7 Some fabrics are made from natural fibres, others are made from man-made fibres. *

B8 The natural fibres are: wool and animal hair, silk made by silkworms, cotton fibres from around the seeds of cotton plants and linen fibres from the stems of flax plants. *

B9 Metals are extracted from the ores by heating with coke or by electricity.

B10 Plastic materials are made from raw materials which we get from coal and oil.

B11 Some plastic materials are made in the form of fibres for use in making fabrics.

B12 Paper is made from wood or from cotton rags.

B13 Rubber comes from a sticky syrup in the trunk of the rubber tree.

B14 Leather comes from the skins of animals.

B15 Most metals are found, joined with other elements, as ores in the ground.

B16 Those metals which do not readily combine with other materials are found in the ground as metals and not as ores.

C MATERIALS IN WATER

C1 Material blocks can be sorted into two sets: those which float and those which sink in water. (Water and... K1)

C2 A small piece of a sinking material can rest upon the surface of water.
(Water and Other Liquids K3)

C3 Some materials dissolve in water and others do not. (Water and... H1)

C4 Some materials absorb water and others are waterproof. (Water and... L1)

C5 Water rises in materials like fabrics, wood, bricks and rocks which have tiny air spaces. (Water and... L2)

C6 Blocks of metal sink in water. (Water K1)

C7 Metal can be made to float by making it into a boat or saucer shape. (Water K4)

C8 Most plastics float in water. (Water K1)

C9 Plastics do not absorb water and they do not rot or rust when they get wet.
(Water and Other Liquids L1)

C10 Most kinds of wood float in water.
(Water and Other Liquids K1)

C11 Wood absorbs water. (Water and... L1)

C12 Wet wood rots.

C13 Fabrics made from cotton, linen or wool soak up more water than fabrics made from man-made fibres.

C14 Fabrics which soak up more water take longer to dry than those which soak up less water, even when the conditions are the same.

C15 Woven fabrics can be treated to make it harder for water to pass through. We call them 'water repellent' fabrics.

C16 Some fabrics shrink after washing.

C17 A material sinks in water if it is more dense than water; materials which float on water are less dense than water.

C18 A small piece of sinking material rests on the surface of water because it is held up by forces in the surface of the water.

C19 Wet wood is made to rot by the micro-organisms which grow in it, using it as food.

D HEATING MATERIALS

D1 Heat changes the appearance of many materials. Some materials, when they are cooled, do not look the same as they did before they were heated.
(Heat A2) (Air an Other Gases D9)

D2 If a metal is heated it eventually reaches a temperature at which it all melts to become a liquid. * ● (Heat B2)

D3 Materials expand when they are heated and contract when they are cooled. (Heat B1)

D4 The expansion of metals is much more noticeable than that of other solid materials.

D5 Metals are conductors of heat. Wood and plastics are heat insulators.
(Heat F1, F2, F3 and F4)

D6 Fabrics which trap a lot of air are good heat insulators. (Heat F7)

D7 Many plastics are flammable. They burst into flames when they are heated. The vapour from many burning plastics is dangerous. *

D8 Some materials, when they are heated, start to burn and they can be used as fuels.
(Heat A3) (Air and Other Gases D6)

D9 Most fabrics burn easily. They are flammable.

D10 Two metals can be used together to make a strip which bends when it is heated. It is called a 'bimetallic strip'.

D11 Some metals burn when they are heated.

D12 Two or more metals can be melted together to make an alloy. Bronze is an alloy made from melting tin and copper together. Bronze is harder than either tin or copper.

D13 When wood is burned in an enclosed space, without much air, it forms charcoal.

D14 Fabrics can be treated to make them flameproof.

D15 When a material is heated its particles vibrate more vigorously and take up more space. That is why materials expand when they are heated.

D16 Some metals expand more than others for the same temperature rise. That is why a bimetallic strip bends when it is heated.

D17 Materials which burn in air combine with the oxygen of the air to form new materials called 'oxides'.

D18 The melting point of most metals is above room temperature, therefore most metals are solids. The melting point of mercury is below room temperature and so it is a liquid metal.

D19 Plastics and wood feel warm because they do not allow the heat from hands to pass through them easily, unlike metals which conduct heat away.

D20 Because they do not conduct heat, plastics and wood can be used as insulators.

D21 When wood or coal burn they are turned into water vapour, carbon-dioxide and a solid which remains as ash.

D22 A fuel is a material which can release energy. When a fuel burns its energy is released as heat.

D23 The warmth of a fabric depends upon its construction and the fibres from which it is made.

E USING AND RE-USING MATERIALS

E1 We choose a material for a particular job from our own knowledge of what it is like, how it behaves and its cost. * (Heat A4) (Electricity D6)

E2 The supply of materials in the world is not endless. We must not waste them. * (Rocks and Minerals E6)

E3 We can often make new things from materials which have already been used. This is called re-cycling. *

E4 When we have burnt fuel materials we cannot re-use them. The world's supply of fuels is being used up. * (Heat A5)

E5 Some of the materials which we want to throw away do not rot and they cause pollution problems if they cannot be re-cycled.

E6 Metals and plastics, when they are melted, can be poured into moulds and they set into shape as they cool. *

E7 The rusting of iron is a great problem because iron which has turned into rust is powdery. It is no longer a metal.

E8 Metals can be protected by covering them with grease, oil, paint, a plastic coating or a thin layer of metal which does not corrode.

E9 Metals can be drawn into wires and they can be hammered or moulded into different shapes.

E10 Metal wire can be made into springs.

E11 Because it does not tarnish, gold is used for jewellery and for protecting the surface of other metals.

E12 Gold and other metals can be made into thin sheets. We call this 'foil' or, if it is very thin, 'leaf'.

E13 A bimetallic strip can be used as an automatic switch to make or break an electrical circuit or as a safety device in gas appliances.

E14 We can use electricity to put a thin layer of a metal onto another metal. This is called 'electro-plating'.

E15 When molten metals are poured into a mould we call this 'casting'.

E16 Plastic materials can be made into solid objects, into thin sheets, into fibres for making fabrics, or into foam.

E17 We can choose the amounts of metals to mix in an alloy so that the alloy has the properties needed for a particular job.

E18 Painting, plating, or greasing a metal prevents corrosion by keeping air and water away from the metal.

E19 The development of plastic objects to replace many of the things which were traditionally made of metal or of wood has resulted in a big increase in the amount of oil and coal used in making plastics.

E20 When we make plastics from coal or oil they can be tailor-made so that they have the right properties for a particular job.

Activities for pupils are listed below, together with references, as suggestions for teachers to consider in preparing an approach to this theme. These activities can be taken together or they can be used individually within other topics as shown in Section 5.2. Most of them will also contribute to core skills and ideas on other maps.

Activity	Reference	Skills Used *	Ideas Developing *	Year	*Minimum* Time Needed
Using the senses to investigate and sort materials	Science 5/13, Like and Unlike, pages 8 - 12, 18 - 20 Nuffield Combined Science Teachers' Guide I, pages 3 - 15 and Activities 1, pages 2 - 5 Science 5/13, Like and Unlike, page 32 Science 5/13, Children and Plastics, pages 12 - 13 Science 5/13, Metals Stages 1 and 2, pages 14 - 18	1,2,3,4,5, 6,7,8,9	A1,A3,A6, A7,A8,A10, A11,C1,C4, C5,C8	1 or 2	3 hours
Looking at fibres and fabrics	Science in a Topic Clothes and Costume, pages 9 - 22 Teaching Primary Science Fibres and Fabrics, pages 8 - 15	1,2,3,4,6, 7,8,9,10	A11,B7,B8, C4,C5,D1, D8,D9	1 or 2	2 hours within a study of clothes
Working with wood: sorting and testing	Science 5/13, Working with Wood, pages 17 - 23, 28 - 31, 33 - 37, 43 - 49, 50 - 51 Science in a Topic Houses and Homes, pages 10 - 11	1,2,3,4,6, 7,8,9	A10,B6, C10,C11, C12,D8, E1	1 or 2	2 hours
Looking at water on different surfaces	Science 5/13, Early Experiences, pages 89 - 90 Science 5/13, Using the Environment Early Explorations, page 18 Nuffield Combined Science Teachers' Gruide II, pages 12 - 14 and Activities 6, pages 15, 18 - 19	1,2,3,4,6, 7,8,9	C4,C9,C11	1 or 2	1 hour overlapping with work on water

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Activity	Reference	Skills Used *	Ideas Developing *	Year	Minimum Time Needed
Investigating wetting and drying	Science 5/13, Early Experiences, pages 84 - 88 Science 5/13, Using the Environment 1 Early Explorations, page 17 Science 5/13, Change Stages 1 and 2, page 48 Teaching Primary Science, Fibres and Fabrics, pages 16 - 18 Science in a Topic Clothes and Costume, page 28 and Houses and Homes, page 26	1,2,3,4,5, 6,7,8,9,10	C4,C5,C9, C11	1 or 2	1 hour overlapping with work on water
Sorting materials into floaters and sinkers	Science 5/13, Early Experiences, page 45 Science 5/13, Like and Unlike, pages 12 - 13 Nuffield Combined Science Teachers' Guide II, pages 16 - 18 and Activities 6, pages 23 - 24	1,2,3,4,5, 6,7,8,9	C6,C8,C10	2	1 hour overlapping with work on water
Testing the strength of materials	Science 5/13, Children and Plastics, pages 28 - 33 Science 5/13, Working with Wood, pages 33 - 37 Science 5/13, Metals, pages 30 - 33, 37 - 40, 43 Teaching Primary Science Fibres and Fabrics, pages 21 - 27	1,2,3,4,6, 7,8,9	A6,E1,E9, E10	2	2 hours
Adding substances to water	Science 5/13, Change Stages 1 and 2, page 56 Nuffield Combined Science Teachers' Guide II, pages 8 - 11 and Activities 6, pages 13 - 14	1,2,3,4,5, 6,7,8,9,	C3	3	2 hours overlapping with work on water
Sorting materials into conductors of electricity and insulators	Explore and Discover, pages 274 - 275 Nuffield Combined Science Teachers' Guide I, pages 357 - 362	1,2,3,4,6, 7,8,9	A4	3	1 hour overlapping with work on electricity

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Activity	Reference o	Skills Used *	Ideas Developing *	Year	*Minimum* Time Needed
Looking for differences between metals and other materials in transferring heat	Nuffield Combined Science Teachers' Guide II, pages 217 - 220	1,2,3,4,6, 7,8,9	D5	4	1 hour overlapping with work on heat

o Details of references are given in Appendix 1

* Skills are listed by number with reference to the sequence of investigation techniques at the beginning of this map.

Ideas are listed by section and number with reference to the preceding pages. An activity may simply contribute to the development of an idea or it may be designed specifically to teach a particular idea.

☐ Pupils develop scientific ideas by working like scientists on practical investigations.

☐ In this area of science pupils will be involved mainly in direct observation of rocks, particularly of those in their own neighbourhood. They will observe rocks used in buildings as well as those making up the terrain.

☐ Ideas about the formation of rocks cannot be presented in the form of practical investigations and, to develop these, children will be involved in discussions, and in learning from books and audio-visual aids.

CORE SCIENCE STARTS HERE

⇩

PART I - INVESTIGATING

⇩

HAVING IDEAS

1. Making a start

   (a) Asking questions which can be answered by observing or experimenting

   For example, 'How many different kinds of rock can we see in our neighbourhood?'

   or (b) Expressing ideas which can be put to the test

   For example, 'This sandy soil holds less water than the clay soil.'

2. Planning observations, fair tests or controlled experiments, in small group discussion, individually or in a whole class

   For example, planning a fair test to put different rocks in order of hardness.

⇩

COLLECTING EVIDENCE

3. Making observations, either directly or from experiments, and measuring when it is appropriate

   (a) looking for similarities and differences between rocks, in colour, hardness, texture, and in effects of dilute acid, using magnifiers when they are helpful and goggles when rocks are being tested;

   (Children will not often be able to identify a rock. The emphasis is on observation rather than labelling. The simple key (Appendix 4) is intended to help teachers when a pupil wants to put a name to a rock he has found).

   (b) looking for signs of crystals or fossils in rocks;

   (c) looking at buildings, at first-hand and also through audio-visual aids, with an interest in the kind of rock which has been used and in distinguishing rock from brick, cement and other man-made materials;

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COLLECTING EVIDENCE (continued)

(d) looking at the landscape around the school in search of features related to the underlying rock;

(e) looking for signs of weathering in buildings or walls;

(f) looking for similarities and differences between soil from different places.

HANDLING EVIDENCE

4. Recording

   Making tables and drawings to record observations.

5. Calculating

   There are calculations which pupils could make from their measurements but none which is a core skill within this theme.

6. Talking in small groups or as a whole class, children will explore and develop their own ideas about their experiences.

7. Trying to classify, order and look for patterns

   Sorting rocks into sets according to colour, hardness, texture, uses, or the effects of dilute acid.

   (The patterns which pupils will see in their observations follow as scientific ideas).

8. Trying to explain in terms of cause and effect

   For example, 'This stone has worn smooth as water has flowed over it'.

   (Explanations of a more sophisticated kind follow as extension ideas).

9. Describing and presenting evidence and ideas

   Children will prepare tables and drawings and they will be talking and writing in their own words.

MAKING USE OF SCIENTIFIC SKILLS AND IDEAS

10. Discussing problems and practical solutions

    For example, considering the purposes for which different rocks are used.

PART II - DEVELOPING SCIENTIFIC IDEAS

	A	WHERE ARE ROCKS FOUND?
CORE ideas are important scientific ideas which the majority of pupils can grasp, by the age of thirteen, in the form in which they are expressed here. They try to show the point reached by the majority of 13-year-olds on their journey towards understanding more formal scientific ideas. Most of the core ideas are patterns which pupils will see in their own practical activities, but there are some which cannot be presented practically and which therefore need verbal or audio-visual teaching; these are indicated by *. ● indicates ideas which pupils have difficulty in grasping but which are so important that they are attempted in the middle years.	A1	The outer layer of the earth is called its 'crust'. It is a layer of rock many kilometres deep. *
	A2	A lot of the earth's surface rock is covered by soil but in places rock shows through the soil.
SUPPLEMENTARY ideas are no more difficult than core ideas, but they are less important.	A3	Although the earth's crust is many kilometres deep, it is as thin, compared with the size of the earth, as the skin on an apple.
	A4	The hot, molten, material under the crust of the earth is called 'magma'.
	A5	Rocks may not always have been formed where we find them. They may have been carried by water or ice.
EXTENSION ideas are more difficult, abstract ideas which may be understood by pupils who have reached a later stage of conceptual development, characterised by abstract thinking.		

B HOW WERE ROCKS FORMED?

(Children will meet the terms 'igneous' and 'sedimentary' but they may not use the words of their own accord).

B1 The first rocks were formed when the molten material of the earth cooled and became solid. *

B2 Rocks that are formed from molten material by cooling are called 'igneous' rocks. *

B3 Rocks can be broken into tiny pieces by wind, rain and ice. *

B4 Over a very long time the small particles from rocks are carried by rivers into the sea where they settle. *

B5 In the sea pieces from rocks, and the skeletons of water animals and plants, settle from the water over long periods of time. *

B6 Layers of settled particles build up at the bottom of a sea and over millions of years they become hard rock as the great weight of the layers above squeezes out the water. * ●

B7 Rocks which are formed from materials settling in water are called 'sedimentary' rocks. *

B8 All the rocks of the earth's surface around Leeds were formed by the settling of particles in a sea which used to cover the area. They are 'sedimentary' rocks. *

B9 All the rocks which are above the sea are constantly being worn away by the weather.

B10 New igneous rocks are still being formed when volcanic lava cools.

B11 The movement of seas and rivers causes pieces of rock to rub together, breaking up into pebbles and small grains.

B12 A volcano is formed from molten rock under the crust of the earth.

B13 Rocks are constantly being worn away to form particles in rivers and seas, and the particles are being deposited and compressed to form new rocks. It would take a rock particle millions of years to complete the cycle from rock to particle and back to rock again.

B14 A rock which has formed by very quick cooling has small crystals of minerals within it. It looks smooth and glassy.

B15 If a rock forms by very slow cooling of molten material, as it would underground, then you can see large crystal forms within it.

B16 Igneous and sedimentary rocks can both be changed by heat and by pressure into another kind of rock called 'metamorphic' rock.

C WHAT ARE ROCKS LIKE?

(The first steps towards recognising rocks are concerned with the skill of observing, in particular with looking for the similarities and differences among rocks described under 'collecting evidence' at the start of this map).

C1 There are so many different kinds of rock that it is very difficult to identify them. Most of them can be identified for certain only by an experienced geologist.

C2 In the area around Leeds we find shales, sandstones, limestone and coal.

C3 Limestone and chalk are sedimentary rocks which may contain the skeletons and shells of water creatures; basalt and granite are examples of igneous rock; sandstone and limestone are examples of sedimentary rock.

C4 Clay is a rock.

D	FOSSILS
D1	Fossils are the remains or traces of some animals or plants which were living millions of years ago. *
D2	Fossils may begin to be formed when an animal or plant is trapped or leaves its print, as a rock is being formed.*
D3	Fossils are found only in sedimentary rocks.
D4	We can tell from fossils what animals and plants must have been like in the past. *
D5	Some of the kinds of plant and animal which we find as fossils are no longer found on the earth.
D6	Oil is a fossil fuel made up of the remains of tiny sea animals which were alive many millions of years ago.
D7	Coal is a fossil fuel made up of the remains of trees and other plants which were alive many millions of years ago.
D8	*Some of the kinds of animal and plant which we find as fossils have died out because conditions on earth have changed, becoming unsuitable for them.*
D9	*Complete fossils are found only in sedimentary rocks because the conditions, under which other kinds of rock are formed, destroy fossils.*
D10	*In any one place the fossils which are founded in deeper rocks are usually older fossils.*

E	USING ROCKS
E1	Some rocks are used just as they are found. Others have materials extracted from them for use. (Materials B1)
E2	A rock from which a metal is extracted is called an 'ore'. Metals are usually found as ores in the ground. (Materials B3)
E3	Not only metals but other useful materials are found in the earth's crust. Coal and oil are important materials because we use them, not only as raw materials but as fuels. * (Materials B1)
E4	Some materials are harder than others and this affects what they can be used for.
E5	Some rocks and minerals are very beautiful. These are used as gems or for building.
E6	The supply of minerals in the world is not endless. We must not waste them. * (Materials E2)
E7	Granite, marble, slate and sandstone are used as building materials. Granite is a particularly useful rock for building because it is so hard.
E8	Clay can be baked into pots and bricks.
E9	Some of our table salt comes from rock salt.
E10	We can make lime from limestone.
E11	Limestone chippings are used as hardcore in making roads.
E12	*The rocks underlying an area affect the land and the plants growing there and therefore the way we can use the area.*
E13	*The wealth of a country is affected by the materials found in, or made from, its rocks.*
E14	*Nearly all the chemicals which we need for making new materials come from rocks.*

F WHAT ARE ROCKS MADE OF?

F1 Most rocks contain a few different kinds of mineral. Minerals make up a rock just as fat, sugar, flour, eggs and raisins make up a fruit cake. * ●

F2 Many of the minerals which we see within rocks are in the form of crystals

F3 Occasionally a mineral is found on its own. For example, we find large pieces of quartz, which is a single mineral.

F4 Some minerals are harder than others and if we have a piece of an individual mineral we can test its hardness.

F5 Quartz is very hard, even harder than steel.

F6 Talc is a very soft mineral.

F7 Diamond is the hardest mineral of all.

F8 In granite we can see quartz, feldspar and mica. They are minerals which make up granite.

F9 A mineral is a single material. A rock is composed of more than one mineral. If the rock is broken into small pieces, the pieces might be composed of different materials.

G SOIL

G1 Soil is a mixture of rock particles, water and decaying animal and plant remains.

G2 The remains of animals and plants in the soil make it fertile.

G3 The tiny particles of rock which make up soil are of different sizes.

G4 Sand and gravel are the larger rock particles in soil.

G5 Clay particles are the smallest rock particles in the soil.

G6 Different soils feel different according to the materials in them. Sandy soils feel gritty and clay soils feel sticky.

G7 The remains of animals and plants in the soil is called 'humus'.

G8 Humus makes a soil dark in colour.

G9 Silt particles feel silky. They are larger than clay particles and smaller than sand particles.

G10 Some soils are acidic; others are alkaline.

G11 Some soils are very shallow; others are deeper.

G12 Acidity can be cured by the use of lime.

G13 Sandy soils have good drainage. Clay soils have poor drainage.

G14 The nature of a soil depends upon the amount of water, air, humus, sand, silt and clay in it.

G15 The nature of soil depends upon the rock it was formed from.

G16 Most soil tends to become acidic in the course of time.

G17 The drainage of clay soils can be improved by adding lime. This makes the small particles of clay clump together allowing water to drain through.

Activities for pupils are listed below, together with references, as suggestions for teachers to consider in preparing an approach to this theme. These activities can be taken together or they can be used individually within other topics as shown in Section 5.2. Most of them will also contribute to core skills and ideas on other maps.

Activity	Reference	Skills Used *	Ideas Developing *	Year	Minimum Time Needed
Looking at rocks in the area around school	Science 5/13, Change 1 and 2, pages 17 - 18 Science 5/13, Using the Environment 2 Investigations Part 2, page 47 Science 5/13, Using the Environment 3 Tackling Problems 2, pages 51 - 52 Schools Council Environmental Studies Project, Starting From Rocks, pages 15 - 29 G.S.Boon, Rocks in Towns, Methuen Science 5/13, Early Experiences, page 45	3,4,5,6,8, 9	A2,B8,C1	2	2 hours
Looking at fossils	Science 5/13, Using the Environment 2 Investigations Part 2, pages 50 - 51 Explore and Discover, pages 205 - 207	3,4,6,7,8, 9	D1,D2,D3, D4	2	1 hour
Looking more closely at pieces of rock	Schools Natural Science Society publication No. 37 Science 5/13, Early Experiences, pages 45 - 46 Schools Council Environmental Studies Project, Starting From Rocks, pages 30 - 38 Science 5/13, Using the Environment 3 Tackling Problems, Part 2, page 52 Schools Natural Science Society publication No. 37	1,2,3,4,6, 7,8,9	B8,C1,E4, E5,F1,F2	3	3 hours
Investigating soil	Science 5/13, Early Experiences, page 51 Science 5/13, Using the Environment 2 Investigations Part 2, pages 53 - 62 Science 5/13, Using the Environment 3 Tackling Problems Part 2, pages 53 - 55 Nuffield Combined Science Teachers' Guide II, pages 162 - 172	1,2,3,4,5, 6,7,8,9,10	G1,G3,G4, G5,G6	3	3 hours

/cont...

ROCKS AND MINERALS 17

Activity	Reference o	Skills Used *	Ideas Developing *	Year	*Minerals* Time Needed
Thinking about how rocks were formed	The Story of the Earth, pages 24 - 35 Science 5/13, Change 1 and 2, pages 17 - 18	3,4,6,7,8, 9	B1,B2,B3, B4,B5,B6, B7,B8,B9	4	2 hours
Getting metals from rocks	Science for the '70s Teachers' Guide 2, pages 52 - 53 Nuffield Combined Science Teachers' Guide II, pages 203 - 210	1,2,3,4,6, 7,8,9,10	E1,E2	4	2 hours

o Details of references are given in Appendix 1

* Skills are listed by number with reference to the sequence of investigation techniques at the beginning of this map.

Ideas are listed by section and number with reference to the preceding pages. An activity may simply contribute to the development of an idea or it may be designed specifically to teach a particular idea.

/ Although pupils are unlikely to be able to identify specimens a key to identifying some of the main rock types is given in Appendix 2 for teachers' information. Sets of rock samples related to this key are available on loan from the John Taylor Teachers' Centre.

5. USING THE MAPS OF CORE SCIENCE IN PLANNING PROGRAMMES OF WORK

5.1 A four-year programme of activities

The following programme is drawn from the sample schemes of work which are offered at the end of each map. It is intended to help the inexperienced teacher by showing *one way* in which activities from different areas of science could be presented within a spiral curriculum. Many of the activities are on-going and overlapping and therefore the time suggested is only a broad guideline.

☐ YEAR ONE

Activity	Relevant Map	*Minimum* Time Needed (hours)
USING OUR SENSES		
Listening, smelling, tasting, looking and feeling	Sensitivity	
Learning to look	Light	
Listening to sounds	Sound	6
Using fingers to feel warmth	Heat	
Using the senses to investigate and sort materials	Materials	
LOOKING AT PLANTS		
Looking for changes in trees	Variety and Adaptation	1
Looking for plants in different places	Variety and Adaptation	2
Looking at flowers	Reproduction	3
Looking at fruits and seeds	Reproduction	2
Growing plants from seeds	Growth	3
Looking for changes in plants	Growth	2
Looking for sensitivity in plants	Sensitivity	1
LOOKING AT ANIMALS		
Looking for animals in different places	Variety and Adaptation	4
Observing birds	Variety and Adaptation	1
Looking for sensitivity in animals	Sensitivity	2
Looking at small animals	Variety and Adaptation	1
Looking for evidence of animals feeding	Food and Feeding	1

Activity	Relevant Map	*Minimum* Time Needed (hours)
WORKING WITH SUN, WIND AND RAIN		
Following the sun and shadows	The Earth in the Universe/Light	1
Making shadow clocks	The Earth in the Universe	1
Looking for reflections	Light	1
Looking at water drops	Water and Other Liquids	½
Measuring rainfall	Water and Other Liquids	1
Looking at water on different surfaces	Water and Other Liquids/ Materials	1
Investigating wetting and drying	Water and Other Liquids/ Materials	2
Making a wind strength indicator	Air and Other Gases	1
Investigating parachutes	Air and Other Gases	1

☐ YEAR TWO

LOOKING AT PLANTS AND ANIMALS		
Observing animal movement	Movement, Forces and Structures	1
Observing animals and their young: life cycles in a variety of animals	Growth/Reproduction	4
Human reproduction	Reproduction	3
Growing plants from fruits and seeds; observing growth	Growth/Reproduction	2
Looking for changes in plants	Growth	1
Looking at fungi	Microscopic Living Things	1
INVESTIGATING CLOTHES		
Looking at fibres and fabrics	Materials	2
Keeping warm	Heat	1
Making electricity	Electricity	½

Activity	Relevant Map	*Minimum* Time Needed (hours)
FINDING OUT ABOUT MATERIALS		
Working with wood	Materials	2
Testing the strength of materials	Materials	2
Making and testing bridges	Movement, Forces and Structures	2
Finding out which materials are attracted to a magnet	Magnets and Magnetism	1
Finding out whether magnets can act through materials	Magnets and Magnetism	½
Making a magnet	Magnets and Magnetism	½
Examining a magnet	Magnets and Magnetism	½
Sorting materials into floaters and sinkers	Water and Other Liquids/ Materials	1
Making sailing boats	Air and Other Gases	1
Looking at water on different surfaces	Materials	1
Looking at some of the effects of air	Air and Other Gases	1
INVESTIGATING LIGHT AND COLOUR		
Looking at hot things	Heat	½
Investigating light	Sensitivity	2
Using lenses and curved mirrors	Light	2
Using coloured light	Light	1
Looking for colour in plants and animals	Light	2
Mixing paints	Light	1
MAKING SOUNDS		
Investigating sounds	Sensitivity	2
Making musical instruments	Sound	2
Finding out what makes sound	Sound	1
Finding out how sound travels	Sound	1
LOOKING AT ROCKS IN THE SURROUNDINGS		
Looking at rocks in the area around school	Rocks and Minerals	2
Looking at fossils	Rocks and Minerals	1

☐ YEAR THREE

Activity	Relevant Map	*Minimum* Time Needed (hours)
LOOKING MORE CLOSELY AT PLANTS AND ANIMALS		
Sorting plants into sets	Variety and Adaptation	1½
Identifying trees	Variety and Adaptation	½
Sorting animals into sets	Variety and Adaptation	4
Finding small animals in compost	Variety and Adaptation	2
Looking at water animals	Variety and Adaptation	1
Measuring changes in the mass of gerbils	Growth	1
Investigating growth	Growth	2
Growing plants from seeds	Growth/Reproduction	3
Investigating the feeding habits of small animals	Food and Feeding	2
Observing the feeding habits of birds	Food and Feeding	1
Discovering food chains	Food and Feeding	1
INVESTIGATING FORCES		
Investigating forces	Movement, Forces and Structures	4
Stretching springs	Movement, Forces and Structures	1
Feeling the pull of the earth	Movement, Forces and Structures	1
Finding the North pole of a magnet	Magnets and Magnetism	½
Finding out how magnets affect one another	Magnets and Magnetism	½
HEATING MATERIALS		
Heating substances	Heat	4
Watching what happens when water is heated	Heat/Water and Other Liquids	1
Measuring temperature	Sensitivity	1
Melting ice and boiling water	Heat/Water and Other Liquids	2½
Finding out about water freezing	Heat/Water and Other Liquids	½

Activity	Relevant Map	*Minimum* Time Needed (hours)
INVESTIGATING AIR		
Looking at some of the effects on air	Air and Other Gases	3
Heating air	Air and Other Gases/Heat	1
Burning candles	Air and Other Gases	2
INVESTIGATING WATER		
Looking at water from different places	Water and Other Liquids	1
Adding substances to water	Water and Other Liquids/ Materials	2
Trying to make rock salt purer	Water and Other Liquids/ Materials	1
USING ELECTRICITY		
Setting up a circuit with a switch	Electricity	1
Sorting materials into conductors and insulators	Electricity/Materials	1
Finding out more about circuits	Electricity	2
Finding out whether the position of a bulb affects its brightness	Electricity	1
LOOKING AT ROCKS AND AT SOIL		
Looking more closely at pieces of rock	Rocks and Minerals	3
Investigating soil	Rocks and Minerals	3

☐ YEAR FOUR

FINDING OUT MORE ABOUT MOVEMENT		
Making things move more easily	Movement, Forces and Structures	3
Investigating streamlined shapes	Movement, Forces and Structures	1
Looking at simple machines	Movement, Forces and Structures	2

Activity	Relevant Map	*Minimum* Time Needed (hours)
FINDING OUT MORE ABOUT ELECTRICITY		
Investigating the link between electricity and magnetism	Electricity	1
Using electricity to make magnets and making an electromagnet	Magnets and Magnetism	1
Making a current balance	Magnets and Magnetism	1
Using ammeters to measure current	Electricity	2
Making batteries	Electricity	1
Finding out about electricity passing through our bodies	Electricity	1
Investigating the heating effect of electricity	Electricity	2
Thinking about energy	Electricity	1
INVESTIGATING AIR AND ITS PART IN BURNING		
Weighing air	Air and Other Gases	1
Investigating air pressure	Air and Other Gases	5
Finding out about oxygen and nitrogen - investigating burning	Air and Other Gases	2
Finding out how much of the air is oxygen	Air and Other Gases	1
Looking at the air we breathe out	Air and Other Gases	½
Making and using carbon-dioxide	Air and Other Gases	1½
WORKING WITH MICRO-ORGANISMS		
Looking more closely at very small living things	Microscopic Living Things	5
Preventing soup or gravy from going bad	Microscopic Living Things	2
Finding out where bacteria are to be found	Microscopic Living Things	2
Looking for micro-organisms in food	Microscopic Living Things	2½
Finding out how fast bacteria can grow	Microscopic Living Things	1
Killing harmful micro-organisms	Microscopic Living Things	2

Activity	Relevant Map	*Minimum* Time Needed (hours)
HEATING MATERIALS		
Heating and cooling air, water and solids	Heat	1½
Looking for differences between metals and other materials in transferring heat	Materials	1
STUDYING ROCKS AND MINERALS		
Thinking about how rocks were formed	Rocks and Minerals	2
Getting metals from rocks	Rocks and Minerals	2
BEGINNING TO THINK ABOUT THE UNIVERSE		
Thinking about the earth, other planets and the stars of the universe	The Earth in the Universe	2

5.2 Science in topic work

Science, particularly for younger pupils, may take the form of broad, perhaps integrated, topics. Suggestions for activities making up the science component of a number of topics are presented below, together with references and an indication of the core scientific skills and ideas which are likely to be developed.

The following topics are dealt with although, of course, they represent only a few examples:

Ourselves
Boats
Time
Weather
Trees
Colour
Clothes
Exploring the environment around school

☐ TOPIC : OURSELVES

Scientific Activity	Reference °	Skills Used *	Ideas Developing *
How tall are you?	Science 5/13, Ourselves, page 5	1,2,3,4,6, 7,9	Variety and Adaptation D2
How heavy are you?	Science 5/13, Ourselves, pages 5 - 6	1,2,3,4,6, 7,9	Variety and Adaptation D2
How well can you see?	Science 5/13, Ourselves, page 15	1,2,3,4,5, 6,7,9,10	Variety and Adaptation D2 Sensitivity A1,A2,A3
How good is your hearing?	Science 5/13, Ourselves, page 24	1,2,3,4,5, 6,7,9,	Variety and Adaptation D2 Sensitivity A1,A2,A3
Guessing sounds	Science 5/13, Ourselves page 3	1,2,3,4,6, 7,9	Sound A2,A3,A4 Sensitivity A4
How good a sense of smell have you?	Science 5/13, Ourselves page 26	1,2,3,4,6, 7,9	Sensitivity B1
Feeling with fingers and toes	Science 5/13, Ourselves pages 31, 41	1,2,3,4,6, 7,8,9	Sensitivity A3,A4,A6 Heat F5 Materials A3
Jumping up	Science 5/13, Ourselves, pages 32 - 33	1,2,3,4,5, 6,7,9	Movement, Forces and Structures E2,E3
How much can your hand pick up?	Science 5/13, Ourselves, pages 36 - 37	1,2,3,4,5, 6,7,9	Variety and Adaptation D2
Fingerprints	Science 5/13, Ourselves, page 41	1,2,3,4,6, 7,9	Variety and Adaptation D2
How well can hands judge temperature	Science 5/13, Ourselves, page 42	1,2,3,4,6, 7,9	Sensitivity A6,D1,D2 Heat E7

☐ TOPIC : BOATS

Scientific Activity	Reference ○	Skills Used *	Ideas Developing *
Making model boats	Science 5/13, Early Experiences, pages 22 - 23 Science 5/13, Science from Toys, page 44 Science in a Topic, Ships, pages 6 - 11 Science 5/13, Like and Unlike, pages 12 - 13	1,2,3,4,6, 7,8,9,10	Water and Other Liquids K1, K2,K4,L1 Materials C1,C4,C6,C7 Movement, Forces and Structures A2,E7
Finding out how salt water affects floating	Science in a Topic, Ships, pages 16 - 17	1,2,3,4,6, 7,8,9,10	Materials A12
Making boats move	Science 5/13, Science from Toys, pages 38 - 41 Science in a Topic, Ships, pages 41 - 50 Science 5/13, Early Experiences, pages 22 - 23	1,2,3,4,6, 7,8,9,10	Movement, Forces and Structures A2,D6 Air and Other Gases B1, B2,B3 Water and Other Liquids F6
Finding the best shape for a boat	Science 5/13, Science from Toys, pages 41 - 44 Science in a Topic, Ships, pages 19 - 22	1,2,3,4,6, 7,8,9,10	Movement, Forces and Structures A2,E1,E7

☐ TOPIC : TIME

Making shadow clocks	Science 5/13, Early Experiences, pages 4 - 10 Science 5/13, Time, pages 9 - 13	1,2,3,4,6, 7,8,9.10	The Earth in the Universe E4 Light and Colour A12
Making water clocks	Science 5/13, Time, pages 14 - 18	1,2,3,4,5, 6,7,8,9,10	Water and Other Liquids A1
Making a candle clock	Science 5/13, Time, pages 19 - 20	1,2,3,4,5, 6,7,8,9,10	-
Timing things	Science 5/13, Time, pages 5 - 7 Science in a Topic, Moving on Land, page 48	1,2,3,4,5, 6,7,8,9,10	-
Finding out how quick you are	Science 5/13, Ourselves, pages 47 - 49	1,2,3,4,5, 6,7,8,9	-

☐ TOPIC : WEATHER

Scientific Activity	Reference ○	Skills Used ■	Ideas Developing ★
Following the sun	Science 5/13, Early Experiences, pages 4 - 5	1,2,3,4,6, 7,9	The Earth in the Universe E4
Making wind strength indicators	Science 5/13, Change, page 16 Science 5/13, Early Experiences, page 16 Science 5/13, Using the Environment 2 Investigations Part 2, pages 9 - 14	1,2,3,4,6, 7,8,9,10	Air and Other Gases B2
Measuring rainfall	Science 5/13, Early Experiences, page 89 Science 5/13, Using the Environment 2 Investigations Part 2, pages 4 - 6 Science 5/13, Using the Environment 3 Tackling Problems Part 2, page 32	1,2,3,4,6, 7,8,9,10	-
Looking at clouds	Science 5/13, Early Experiences, pages 14 - 15 Science 5/13, Using the Environment 2 Investigations Part 2, page 8 Science 5/13, Change, page 23	1,2,3,4,5, 6,7,8,9,10	-
Measuring air temperature	Science 5/13, Using the Environment 2 Investigations Part 2, pages 18 - 19	1,2,3,4,5, 6,7,8,9,10	Sensitivity A6,D2 Heat E1,E2,E6,E7
Investigating snow and ice	Science 5/13, Early Experience, pages 92 - 94 Science 5/13, Using the Environment 2 Investigations Part 2, page 7	1,2,3,4,6, 7,8,9,10	Heat B2 Materials D2 Water and Other Liquids D1

☐ TOPIC : COLOUR

Mixing paints	Science 5/13, Coloured Things, page 5	1,2,3,4,6, 7,8,9,10	Light and Colour C1,C2
Matching colours	Science 5/13, Change Stages 1 and 2, pages 58 - 59	1,2,3,4,6, 7,8,9,	-
Investigating with coloured light	Science 5/13, Coloured Things, pages, 15, 43	1,2,3,4,6, 7,8,9,10	Light and Colour F5
Making a spectrum	Science 5/13, Coloured Things, pages 15, 31 Science 5/13, Using the Environment 1 Early Explorations, page 15	1,2,3,4,6, 7,8,9	Light and Colour F1,F2,F3, F4

/cont...

Scientific Activity	Reference	Skills Used	Ideas Developing
Finding the safest colour for a car	Science 5/13, Coloured Things, pages 35 - 36	1,2,3,4,6, 7,8,9,10	-
Finding the best colours for making traffic signs	Science 5/13, Coloured Things, pages 37 - 38, 40	1,2,3,4,6, 7,8,9,10	-
Dyeing Fabrics	Science 5/13, Coloured Things, pages 52 - 56 Science in a Topic, Clothes and Costume, pages 53 - 56 Science 5/13, Change Stages 1 and 2, page 34	1,2,3,4,6, 7,8,9,10	-
Looking for colour in animals and plants	Science 5/13, Coloured Things, pages 19 - 30 Science 5/13, Using the Environment: 1 Early Explorations, page 33, 2 Investigations Part 1, page 21	1,2,3,4,6, 7,8,9	Light and Colour D1 Variety and Adaptation B1,D1

TOPIC : CLOTHES

Finding out about keeping warm	Science 5/13, Early Experiences, page 67 Science in a Topic, Clothes and Costume, page 24 Science 5/13, Using the Environment 2 Investigations Part 1, pages 74 - 75	1,2,3,4,6, 7,8,9,10	Heat F7 Materials D6
Finding out about wetting and drying clothes	Science 5/13, Early Experiences, pages 84 - 88 Science 5/13, Using the Environment 1 Early Explorations, page 17 Science in Topic, Clothes and Costume, page 28 Teaching Primary Science Fibres and Fabrics, pages 16 - 18 Science 5/13, Change Stages 1 and 2, page 48	1,2,3,4,5, 6,7,8,9,10	Water and Other Liquids F5, G1,G2,G3,G4,L1,L2 Materials C4,C5 Air and Other Gases G1,G4
Looking at fabrics and fibres	Science in a Topic, Clothes and Costume, pages 9,18,21 Teaching Primary Science Fibres and Fabrics, pages 8 - 15	1,2,3,4,6, 7,8,9,10	Materials A11,B7,B8,C4,C5, D1,D8,D9
Testing the strength of fabrics and fibres	Science in a Topic, Clothes and Costume, pages 19 - 20, 22 Teaching Primary Science Fibres and Fabrics, pages 21 - 27	1,2,3,4,5, 6,7,8,9,10	Materials A6,E1,E9,E10

☐ TOPIC : TREES

Scientific Activity	Reference °	Skills Used *	Ideas Developing *
Looking for changes in deciduous trees	Science 5/13, Using the Environment 2 Investigations Part 1, pages 42 - 44	1,2,3,4,6, 7,8,9	Variety and Adaptation B1,B2,B3,B4,B5
Planting seeds	Science 5/13, Trees, pages 27 - 28	1,2,3,4,6, 7,8,9	Growth A3,B3,C1,C2 Reproduction F4,F5,F6
Studying leaves	Science 5/13, Using the Environment 1 Early Explorations, pages 28,32 Science 5/13, Using the Environment 2 Investigation Part 2, page 32 Science 5/13, Using the Environment 3 Tackling Problems Part 2, page 69 Science 5/13, Trees, pages 13 - 18, 19 - 21	1,2,3,4,6, 7,8,9	Variety and Adaptation B1,B2
Making measurements ø	Science 5/13, Trees, pages 33 - 36, 67	1,2,3,4,5, 6,7,8,9,10	Variety and Adaptation B1,B2
Working with twigs	Science 5/13, Trees, pages 39 - 43	1,2,3,4,6, 7,8,9	-
Making a tree survey	Science 5/13, Trees, pages 28 - 31	1,2,3,4,5, 6,7,8,9	Variety and Adaptation B1,E1
Looking at wood	Science 5/13, Working with Wood, pages 41, 63	1,2,3,4,6, 7,8,9	Growth A5

ø The approximate age of a living tree can be found by measuring the circumference in inches of the trunk. Each inch represents one year's growth.

° Details of references are given in Appendix 1

* Skills are listed by number with reference to the sequence of investigation techniques on page 6 and at the beginning of each map.

Ideas are listed by reference to individual maps.

☐ TOPIC : EXPLORING THE ENVIRONMENT AROUND SCHOOL

Exploration of the environment surrounding school may take the form of a long-term project from which all other scientific investigations emerge. Alternatively it may take the form of many short-term surveys or investigations. In any approach teachers will find invaluable guidance in the six books, entitled 'Using the Environment' in the Science 5/13 series.

Science 5/13

'Using the Environment'

1. Early Explorations
2. Investigations Part 1
   Investigations Part 2
3. Tackling Problems Part 1
   Tackling Problems Part 2
4. Ways and Means

Activity	Reference ○
Learning to look and to use other senses	Early Explorations, pages 6 - 21, 58 - 66 Investigations Part 1, pages 20 - 26
Estimating, counting and measuring, sampling	Early Explorations, pages 36 - 57 Investigations Part 1, pages 26 - 32 Tackling Problems Part 2, pages 3 - 12,19 - 31
Observing behaviour of animals	Investigations Part 1, pages 52 - 66
Testing materials	Investigations Part 1, pages 67 - 81
Making collections, sorting and ordering	Early Explorations, pages 28 - 37
Observing changes in weather	Investigations Part 2, pages 3 - 20
Investigating the landscape, rocks and soil	Investigations Part 2, pages 47 - 62 Tackling Problems Part 2, pages 49 - 58
Work with birds	Investigations Part 2, pages 82 - 99
Looking for changes in animals and plants	Investigations Part 2, pages 21 - 45
Studying form and function in animals and plants	Tackling Problems Part 1, pages 31 - 62
Looking for ways in which animals and plants vary and in which they are fitted to their environment	Tackling Problems Part 1, pages 64 - 76
Thinking about the interdependence of living things	Tackling Problems Part 1, pages 11 - 28

Guidance on developing habitats within school grounds, and on equipment and resources is given in 'Ways and Means'.

Investigations proposed in the above references give pupils the opportunity to use all the core scientific skills, described in each of the maps and on pages 5 - 7, and to develop many of the core scientific ideas.

○ Details of references are given in Appendix 1

References for pupils' activities

The following sources are those which have been used in the sample schemes of work following each map:

1. The Science 5/13 Project: Schools Council, Macdonald, 1974.

   Early Experiences
   Time
   Structures and Forces (Stages 1 and 2)
   Working with Wood
   Science from Toys
   Holes Gaps and Cavities
   Metals (Stages 1 and 2)
   Charge (Stages 1 and 2)
   Minibeasts
   Ourselves
   Like and Unlike
   Coloured Things
   Trees
   Children and Plastics
   Early Explorations
   Investigations Parts 1 and 2
   Tackling Problems Parts 1 and 2
   Ways and Means
   } Using the Environment

2. Nuffield Combined Science: Nuffield Foundation, Longman, 1970.

   Teachers' Guides I and II
   Activities 1 - 10

3. Science for the Seventies: Scottish Education Department, Heinemann, 1972.
   Teachers' Guides, Books 1 and 2

4. Biology for the Individual: Reid and Booth, Heinemann, 1971.

   Sorting Animals and Plants into Groups
   How Life Begins
   Movement in Animals
   Support in Animals and Plants
   Problems in Life in Cold, Hot and Dry Climates
   Working with Very Small Things
   War against Disease
   Plant Reproduction

5. Science in a Topic: Kincaid and Coles, Hulton, 1979.

   Ships
   Houses and Homes
   Clothes and Costume
   Communication
   Food
   Moving on Land
   Roads, Bridges and Tunnels

6. Teaching Primary Science: Nuffield Foundation/Social Science Research Council, Macdonald, 1976.

   Candles
   Seeds and Seedlings
   Paints and Materials
   Science from Water Play
   Fibres and Fabrics
   Mirrors and Magnifiers
   Science from Wood
   Musical Instruments
   Aerial Models

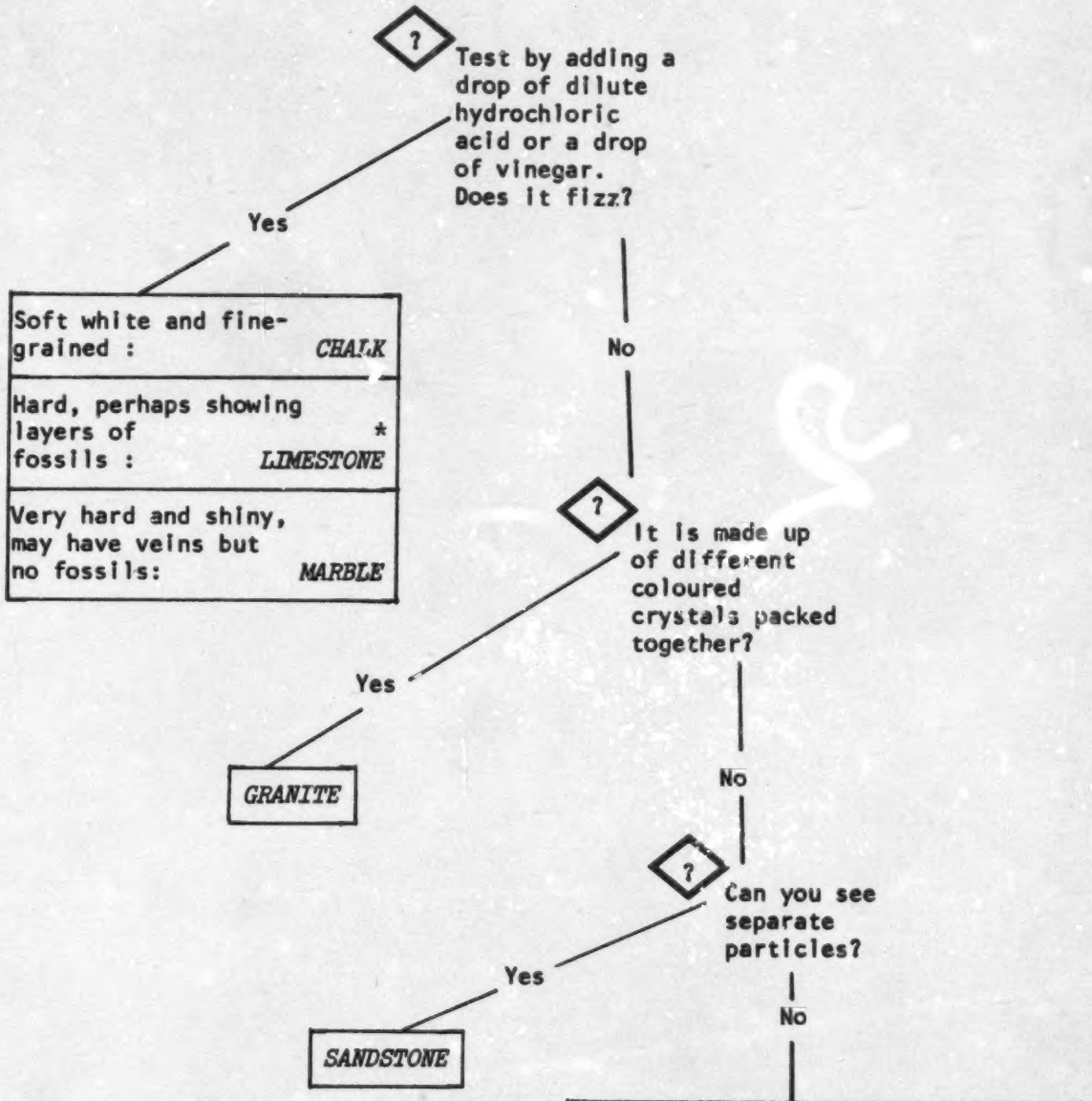
7. New Unesco Source Book for Science Teaching, The Unesco Press, 1973.

8. Explore and Discover, Darke and Hughes, McGraw-Hill, 1974.

9. Schools Council Environmental Studies Project, Starting from Rocks, Hart-Davis, 1973.

Key to identifying rock types for teachers' use

Although it is very difficult to identify any particular rock, pupils very often want to 'put a name' to a rock they find and it may be possible to say which group a rock belongs to. The following very simple key is intended to help teachers to respond to those pupils who want to take a few first steps towards identification.


?
Test by adding a drop of dilute hydrochloric acid or a drop of vinegar. Does it fizz?
Yes
No
Soft white and fine-grained : CHALK
Hard, perhaps showing layers of fossils : * LIMESTONE
Very hard and shiny, may have veins but no fossils: MARBLE
?
It is made up of different coloured crystals packed together?
Yes
No
GRANITE
?
Can you see separate particles?
Yes
No
SANDSTONE
Made up only of small pieces of sand : * SANDSTONE
Contains bigger pieces like pebbles as well as sand : * GRIT
Soft like plasticine : *CLAY
In thin layers : *SHALE
Hard, splits in more more than one direction : SLATE
Very hard, splits with curved surfaces, dark interior, light surface : FLINT
Light weight, black, forms splinters : *COAL

* Rocks found in the Leeds area

Progress in skills of investigation

Throughout the four years of middle school pupils who regularly take part in practical investigations will be able to make considerable progress in each of the skills of investigation described on pages 6 and 7 and at the beginning of each map:

1. Making a start by
   (a) asking questions which can be answered by observing or experimenting;
   (b) expressing ideas which can be put to the test
2. Planning observations, fair tests or controlled experiments
3. Making observations and measuring when it is appropriate
4. Recording
5. Calculating
6. Talking in small groups or in class discussion
7. Trying to classify, order and look for patterns in observations
8. Trying to explain observations
9. Describing and presenting
10. Making use of scientific skills and ideas.

In the following pages a sequence of development is suggested for most of these skills. The sequences proposed are a first attempt to describe stages of development and they represent an area of interest where more work is needed to draw upon teachers' experience of children's progress. Although tentative, and not related to age of pupils, these suggestions will perhaps help teachers to ensure that pupils do extend and refine their skills of investigation.

1. Progress in (a) asking questions which can be answered by observing or experimenting and (b) expressing ideas which can be put to the test

   Raising numerous, but often vaguely expressed, questions and ideas yet not persisting in seeking answers or testing ideas; not able to distinguish between ideas and questions which lead to practical evidence and those which do not.

   Becoming more interested in questions and ideas raised by the teacher and by other pupils- becoming more thoughtful in formulating questions and ideas and drawing upon experience; beginning to recognise and value those questions and ideas which lead to observation and experiment but often expressing them too vaguely to be helpful in planning investigations.

Stage reached ▷ by most 13-year-old pupils

Developing the habit of asking precise questions, like 'What does it do when....?' and 'What will happen if....?', or expressing ideas clearly by making predictions which can be tested; perhaps expressing fewer, less spontaneous ideas and questions but using previous experience and having plans for collecting evidence; beginning to raise questions of how things happen the way they do and trying to explain in terms of cause and effect.

Consistently formulating precise, detailed questions and ideas which lead to observation and experiment and which draw upon knowledge and experience; regularly raising questions of how things happen the way they do, and ready to consider theoretical explanations.

2. Progress in planning observations, fair tests and controlled experiments

Using given equipment and instructions to make a prescribed investigation planned by the teacher.

Deciding to make simple direct observations, not yet setting up situations for collecting evidence.

Beginning to plan a set of observations to be made and occasionally setting up a situation to observe events which may not otherwise happen when pupils want to observe them.

Stage reached ▷ by most 13-year-old pupils

Accepting that observations need to be made in circumstances which are fair, but often not noticing ways in which things are not fair until reminded by the teacher; able to devise ways of making fair observations when unfairness is noticed or pointed out.

Beginning to design experiments taking account of variables and controlling many of them without a teacher's prompting.

Regularly designing experiments in which only one condition is varied at a time.

3. Progress in making observations and measuring when it is appropriate

Aimlessly looking, noticing only the most obvious characteristics or events; noticing only relative size, speed or brightness etc. but not interested in making measurements.

More actively involved in observing, noticing details and beginning to recognise similarities and differences; using several senses, not only sight, and becoming interested in measuring whenever it is possible, at first in arbitrary units and then in standard units using measuring equipment; beginning to use optical aids but indiscriminately.

Stage reached by most 13-year-old pupils ▷ Making more purposeful observations from growing understanding; beginning to look for characteristics and events which are expected; beginning to make estimates, for example of distance or mass; beginning to recognise that some observations or measurements are more useful than others in relation to questions and ideas which have been expressed; becoming more selective in the use of measuring devices and optical aids; beginning to check observations and measurements and to calculate averages.

Regularly checking observations and measurements; regularly using average figures derived from repeated measurements; regularly selecting the best optical aid or measuring device for the job; able to calculate scale of magnification.

4. Progress in Recording

Making a record of observations and ideas only when asked by the teacher, and often seeking guidance on what to write; recording by drawing and making models, collages.

Beginning to see the need for records of observations and measurements but needing help in planning tables in which to record; gaining confidence in descriptive recording without a teacher's guidance on wording but unable to select the most important items for recording and not always achieving a coherent account.

Stage reached by most 13-year-old pupils ▷ Getting into the habit of keeping a working record of observations and measurements (using symbols in describing electrical circuits) yet still needing help in planning tables for recording; making graphs to represent tables of measurements or observations given the teacher's help in selecting scales; developing the habit of expressing ideas and plans for future investigations as well as recording events.

Keeping careful personal records of observations and measurements at the time of practical investigations; consistently writing concise and accurate accounts, using drawings, tables and graphs when they are appropriate, without a teacher's guidance. Interpreting graphs and tables prepared by others.

5. Progress in calculating

Handling numbers and measurements from observations simply by recording them without any calculation.

Calculating changes from 'before' and 'after' measurements of size, weight, temperature or time.

Calculating the size or weight of one of a group of equal objects by measuring the group and dividing by the number in the group.

Stage reached by most 13-year-old pupils ▷ Calculating average figures from a number of measurements with the help of the teacher; calculating speed or the mass of $1cm^3$ of a material under guidance from the teacher.

Regularly calculating averages from repeated measurements; making calculations, such as deriving speed or density, from a grasp of the concept and without a teacher's guidance.

6. Progress in talking in small groups

Most pupils are more willing to take part in discussion in small groups than in a whole class. It is in this context that they can try out and develop their ideas, explore possibilities in planning observations and experiments, and reflect upon their experiences so as to reach new understandings.

Talking within small groups, before and after practical investigations, plays a key role in harnessing a pupil's previous experience and in developing understanding from practical activities. Pupils often need to be given a goal or focus for discussion. They need a regular habit of discussion if they are to develop the skills of presenting ideas, listening to others and reaching shared conclusions which they can express with confidence to a larger audience.

(Teachers will find helpful guidance on small group discussion in 'From Communication to Curriculum', D. R. Barnes, Penguin, 1976).

7. Progress in trying to classify, order and look for patterns in observations

Noticing similarities and differences but not yet grouping on the basis of these; arranging in order according to visible characteristics.

Sorting objects, materials or living things into sets according to one characteristic.

Sorting according to a number of different criteria and recognising that some criteria are more useful than others; recognising regular visual patterns in objects and in living things.

Stage reached by most 13-year-old pupils ▷ Looking with a teacher's help for order and pattern in tables of observations or measurements and expressing these as generalisations; able to use a simple key often needing help from the teacher.

Consistently recognising order and pattern, not only visual patterns but also patterns in observations and measurements; accurately expressing the patterns seen in observations as a conclusion or generalisation without a teacher's guidance, using a key for identification of living things without a teacher's guidance; constructing a key for identification based upon similarities and differences observed.

8. Progress in trying to explain observations

Uninterested in offering explanations of events, so that recording is merely descriptive.

Beginning to try to explain things when prompted by the teacher but often unable to explain how a cause gives rise to a particular effect.

Stage reached by most 13-year-old pupils ▷ Getting into the habit of looking for and attempting explanations without prompting from the teacher, able to see a link between effects and their causes.

Beginning to seek and accept explanations in theoretical terms describing what is happening 'behind the scenes'.

9. Progress in describing and presenting observations and ideas to others

Describing verbally and in models or drawings; often needing a teacher's prompting to achieve a complete and coherent account or representation.

Describing in writing, often needing a teacher's prompting to achieve a complete and coherent account.

Stage reached by most 13-year-old pupils ▷ Selecting, with a teacher's help, the best means of presenting observations and ideas; sometimes needing help in expressing ideas clearly yet generally ready to describe and explain events and phenomena in own words.

Consistently presenting, through a variety of techniques, a clear and coherent account to others.

10. Progress in making use of scientific skills and ideas

Clearly as skills and ideas are developed pupils will have at their disposal greater resources for solving problems and making useful things.

Very often the need for a testing or measuring device presents opportunity for pupils to design and make a useful item. Alternatively pupils can be presented with the task of designing and making something useful for others.

Many scientific investigations take the form of problems when we make a start by asking a question.

Through all these approaches pupils recognise science not as an activity for its own sake but as a way of making life better for people and as a way of making ourselves more capable.

Equipment and Materials

The following equipment and materials are useful for activities listed in the sample schemes of work accompanying the maps:

1. Equipment

Acrylic tubing
Ammeters
Aquarium tanks

Balances: top-pan, lever-arm, spring, bathroom-scales
Beakers: 100cm^3, 250cm^3 and 1,000cm^3 (glass and plastic)

Blue glass
Bottles
Buckets
Bulbs
Bulb-holders
Bunsen burners

Centrifuge
Circuit boards, connectors
Clamps, clamp stands
Clinical thermometers
Clinometer (home-made)
Compasses, magnetic
Conical flasks
Corks

Delivery tubing
Dessicator
Dropping pipettes
Dry cells 1.5V

Evaporating basins

Filter funnels
Flasks (round bottom)
Force indicators: elastic bands, plastic foam, luggage cords

Forcemeters: 0-1N; 0-10N; 0-100N

Forceps

Gas jars
Gauzes, wire
Glass tubing
Glass rod
Goggles - safety

Hand lenses
Heat resistant mats

Jars: assorted

Lenses: concave and convex

Magnets: assorted shapes and sizes
Magnifiers
Masses: assorted 1g to 1kg; slotted
Measuring cylinders, jugs and jars
Mirrors: plane, concave and convex
Mortar and pestle

Paint brushes
Petri dishes
Plant pots
Plastic bags and carriers
Plastic boxes
Plugs (3 pin - 13 amp)
Polystyrene cutter
Pressure cooker
Prisms

Rain guage (home made)
Regrigerator
Rubber bungs assorted
Rubber tubing (including pressure tubing)
Rulers: 15cm, 30cm, 50cm, 100cm

Safety screens and stands
Scissors
Slides - microscope (including cavity slides)
Slide projector
Springs: assorted
Statistics frame (or home-made equivalent)
Stop-clocks
Switches
Syringes: 2cm^3, 5cm^3, 50cm^3

Tape measures
Test-tubes and racks
Thermometers, stirring: -10°C to 110°C and -10°C to 240°C
Tillich's bricks
Tins and tin lids
Tongs
Tripods
Tuning forks
Trundle-wheel

2. Materials

Art straws

Aluminium foil

Agar jelly

Balls: assorted

Balsa wood

Bricks

Breeze block

Cardboard, sheets and tubes

Carpet pieces: assorted

Cobalt chloride (crystals or paper)

Copper wire bare (26 swg) and plastic coated

Cotton-wool

Dilute hydrochloric acid

Disinfectant

Elastic materials (rubber bands, plastic foam, pencil-rubbers)

Ethanol

Fabrics: assorted pieces

Filter papers

Formica pieces

Glue

Graph paper

Guttering (plastic)

Indicator (solution and/or paper)

Instrument strings/wire

Leather pieces

Linoleum pieces

Materials for testing (plastics, wood, metals, etc.)

Meat extract

Milton

Paper: assorted sizes, colours, thicknesses

Parafilm

Pins

Plasticine

Polycell paste

Polystyrene beads

Pond water

Rock samples (available on loan from the John Taylor Teachers' Centre)

Rock salt

Rubber bands

Sand

Sandpaper

Slate

Sodium hydroxide

Soil samples

Sticky paper

Sticky tape

Straws: drinking

String

Sugar

Test-rigs (home made)

Thread

Ticker tape (sticky-backed)

Toy cars

Wire: assorted including plastic coated

Wood: assorted pieces

Yeast

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This project has been supported and advised by a Consultative Committee composed of the following members:

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